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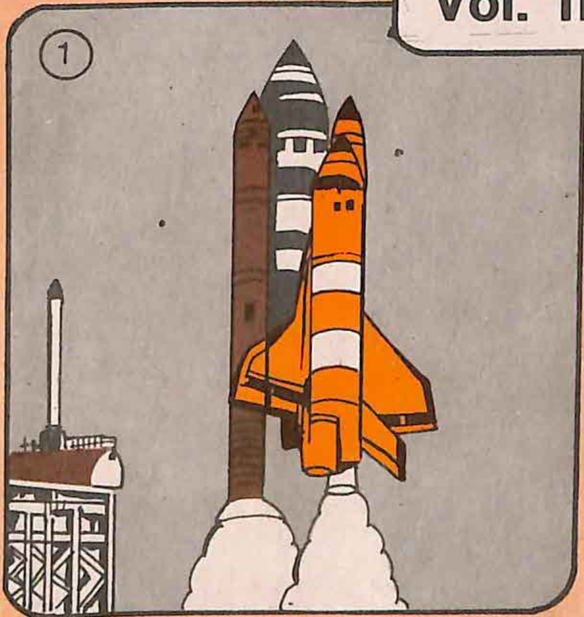
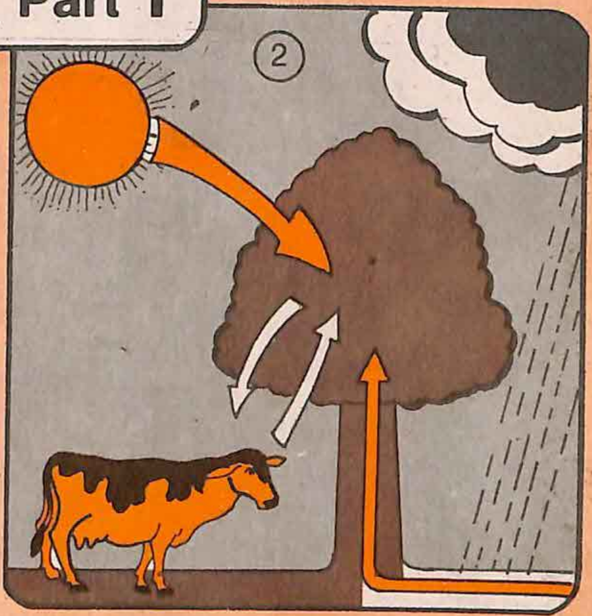
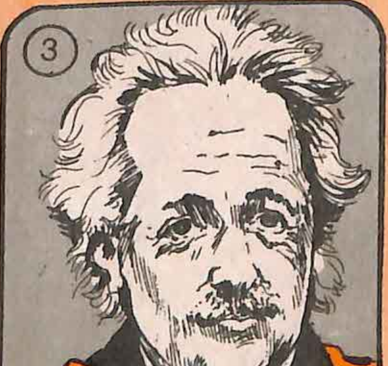
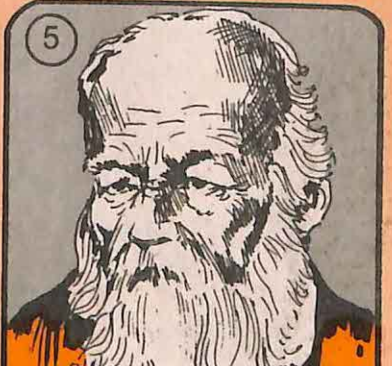
Vol. II Part I









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PREFACE

This volume covers Units I and V of the Science syllabus for Class X prescribed by the Central Board of the Secondary School, New Delhi, for the Secondary School Certificate Examination under the Delhi and All India Schemes.

The contents of the two units, viz., Unit I (Energy) and V (Universe) are divided into chapters to make the study of the subject systematic and easy to follow. The book contains the latest information on each topic. Each concept has been explained lucidly and illustrated with diagrams, wherever possible. The language is easy to understand.

Learning objectives have been given in the beginning of each chapter. *Summary* of each chapter has been given at the end of the text for quick revision.

At the end of each chapter questions are also given which are varied in nature like *very short answer and essay type questions.* All the questions bear a direct relevance to the subject-matter of the chapter.

I hope the book will prove useful for the students.

Suggestions for the improvement of the book will be gratefully received and acknowledged.

May, 1991 S.M. BHATNAGAR

Latest Syllabus Prescribed by the CBSE for Class X

Unit I : Energy

Sun as a source of energy : absorption of solar energy by earth, photosynthesis, solar heaters, solar cells.

Winds : windmills; Hydroelectricity - generation, electricity from sea-waves; Bio-energy, biomass, bio-mass as fuel, biogas.

Fossil fuels : sources of fossil fuels, natural fuels, conditions for combustion, heat produced during combustion, combustion of food in living organism.

Types of fuels : energy from fuels, solid, liquid and gaseous fuels, characteristics of fuels—conditions for combustion, heat produced during combustion, food in living organism.

Internal and external combusion engine : Mechanical work and heat, mechanical equivalent of heat (J) , power, working principle of internal combustion engine, types of internal combustion engine, external combustion engine.

Nuclear energy : nuclear fission, energy released during fission, atomic power plants, nuclear fusion, radiation hazards. Energy crisis; causes of energy crisis; possible solutions for overcoming energy crisis.

Unit V : Universe

Earth : physical and biological components, atmosphere, changes since its origin, evolution of life, role of solar energy in origin and sustenance of life.

Space exploration : history of space exploration, applications of space science—satellite communication, weather monitoring, collection of information about other planets and outer space.

Solar system : planets and satellites, structure of the solar system, age of planets including earth.

Universe : Solar System and Milky Way galaxy, stars and constellations, formation of earth, earth a special place, comprising galaxies, expanding universe, origin of universe — big bang theory.

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Chapter 1

ENERGY AND ITS MEASUREMENT

LEARNING OBJECTIVES

1. To know various sources of energy.
2. To understand the uses of Solar Energy in Photosynthesis, Solar Heater and Solar Cell and to know about the composition of Sunlight.
3. To understand that the energy of moving objects can be utilized to produce electricity.
4. To apply the knowledge that the energy in the moving wind and flowing water can produce electricity through windmills and hydroelectric generators, respectively.
5. To gain the knowledge about Bio-energy and its production through Bio-gas plant.
6. To know about the measurement of energy and its unit and to solve simple numerical questions.
7. To understand the conversion of heat energy into mechanical energy and to know their relationship [Work done (W) = Mechanical equivalent of heat (J) x Heat energy (H)].
8. To understand the principle of heat engines and to know the functioning of External Combustion Engine and Internal Combustion Engine.
9. To enlist the differences between the External Combustion Engine and Internal Combustion Engine.

INTRODUCTION

We come across various forms of energy in our daily life. Electrical energy, heat energy, chemical energy, mechanical energy, light energy, etc., are various forms of energy. We also know that a body that can work possesses energy and, as such, energy is defined as the capacity to do work (Fig. 1.1).

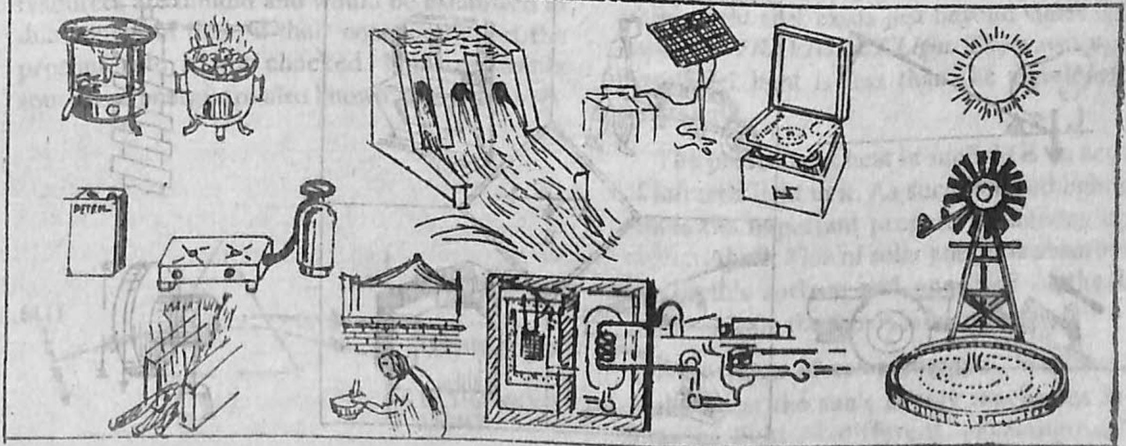

Fig. 1.1 Different sources of energy

MAN AND ENERGY

Man has built a number of wonderful structures by doing hard work. He has the capacity to do work and as such possesses energy. In doing work, he generally uses muscles of his body which we may call *muscular energy*. Man and animals obtain this muscular energy from the food they eat.

Slowly, man has learnt to make use of different aids to make his mechanical work easy. These different aids are called *machines*. Thus, with the use of these machines, man has learnt to get more work done by utilizing less amount of his muscular energy. You might have read about simple machines, like *pulley, inclined plane, screws, lever,* etc., in lower classes. These simple machines reduce the effort required to do mechanical work and thus make the work easier. Later on, man has also learnt to harness the energy available from other sources and put it to his use. It reduces the dependence of man on his muscular energy.

Below are some of the examples showing the use of machines made by man to reduce his effort (Fig 1.2).

EXTERNAL SOURCES OF ENERGY TAPPED BY MAN

We find that besides using his own muscular energy for different pieces of work, man has also learnt to make use of energy available from other different sources. He has learnt to make use of the energy of animals by taking different types of work from them for his use. You might have noted how man has made them carry load from one place to another for his own benefit.

Cooking our food, running a transport or getting production from an industry or a factory, etc., all require energy in some form or the other. Man has tapped various sources of energy and is still making efforts to find out other sources of energy for uplifting his standard of living. We find that the consumption of energy is increasing day by day, urging man to strive for other sources of energy that can continue as such for many more years to come for his different kinds of work.

Initially, man used wood as an external source of energy for getting fire.

Fire has been put to many uses such as cooking food, heating and lighting, etc. Now, for get-

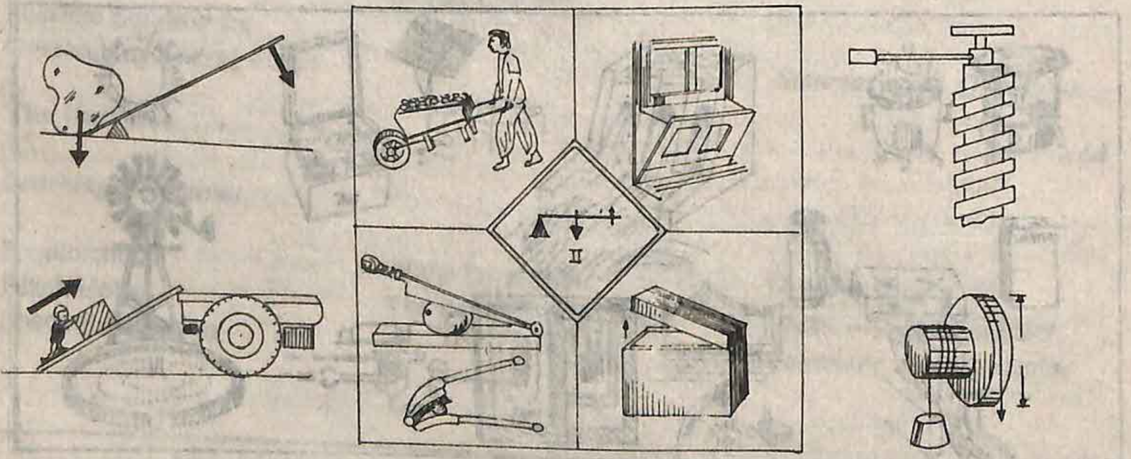

Fig. 1.2 Simple machines

ting fire he burns fuels available in different forms, such as wood, coal, kerosene oil and cooking gas, etc. Man also found the sun as a big source of energy, which is responsible, to a great extent, for life on the earth. Man has noticed the energy in the moving wind and running water. The energy in these sources has also been utilized by man for his benefit in different ways. Later on, man found that the nucleus of uranium can also be tapped for getting energy.

Various sources of energy available can be classified into two categories :

1. Renewable sources of energy;

2. Non-renewable sources of energy.

Renewable sources of energy : These are the sources of energy which are not exhaustible and from which we can get the energy again and again. For example, Sun, wind, flowing water and wastes of animals, etc., are renewable sources of energy.

Non-renewable sources of energy : Non-renewable sources of energy are those which are exhaustible and from which the energy would not be available again and again. For example, coal, oil and petroleum, etc., are non-renewable sources of energy. These sources of energy are formed as a result of decay of plant and animal remains over millions of years. As such their resources are limited and would be exhausted in due course of time, if their consumption at the present rate is not checked. Non-renewable sources of energy are also known as *Fossil Fuels.*

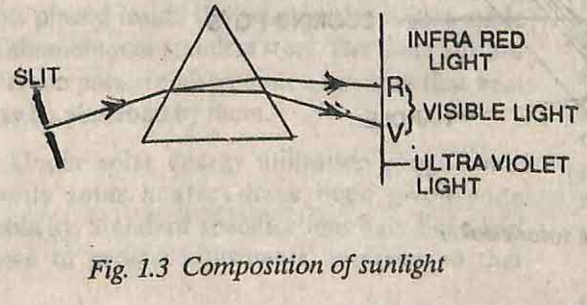

Fig. 1.3 Composition of sunlight

In this chapter we will study more about the renewable sources of energy.

SUN AS A SOURCE OF ENERGY

The sun is the main source of energy for the earth. It is actually responsible for life on this planet — the Earth. The energy that we get from the Sun is known as *Solar Energy.* The energy radiated out from the sun reaches the earth directly. A good portion of this solar energy is absorbed by the earth. Actually the plants on the earth absorb a good part of the solar energy for preparing their food.

Composition of sunlight : Only a small portion of sunlight is visible to us. In earlier classes you might have studied that if sunlight is passed through a prism, we get light of different colours on the screen (Fig. 1.3). This light is called visible light. The extreme colour on one end of this visible light is red and on the other violet. The range of wavelength of this visible light is from 3900×10^{-10}m to 7800×10^{-10}m. The wavelength of violet light is 3900×10^{-10}m whereas the wavelength of red light is 7800×10^{-10}m. In fact beyond the red and violet light also there is light which is not visible to us and is called invisible light. Just beyond red light the invisible light that exists is called *INFRARED Light.* The wavelength of infrared light is more than the wavelength of red light. In the same way the invisible light that exists just beyond violet light is called *ULTRAVIOLET Light.* The wavelength of ultraviolet light is less than the wavelength of violet light.

The presence of heat in sunlight is on account of infrared light in it. As such infrared light possesses the important property of heating up an object. About 47% of solar energy is absorbed by the earth's surface and one-third of the light received from the Sun is infrared light.

Absorption of solar energy : We have just studied that the sun's energy reaches us in the form of light of different wavelengths. The predominant light in the sun's energy is infrared light which is about one-third of the total light received from the Sun. Some of the solar energy is reflected back in space and some is absorbed by the atmosphere. About 47% of this energy is absorbed by the earth's surface. The major part of this energy is absorbed by green plants for converting it into their food. The process by which solar energy is trapped by green plants and converted into food is called *photosynthesis.* During photosynthesis, plants make their food from water and carbon dioxide in presence of Sunlight. The reaction involved in the photosynthesis can be represented in the simple form as

$6CO_2 + 6H_2O$ + Sunlight – – >

$C_6H_{12}O_6 + 6O_2$

Starch (carbohydrate)

Carbon dioxide + Water + Sun's energy

– – > Carbohydrate + Oxygen

As such we see that photosynthesis is a natural process by which oxygen is liberated for use by man and animals. During photosynthesis plants mainly absorb the violet and red lights. The light of remaining wavelengths especially the green light is reflected back. On account of this reason plants look green.

Devices have been found to utilize solar energy in the form of solar heaters, for cooking food and in the form of solar cell for lighting purposes. Now, we will discuss these devices in detail.

Solar heaters : Solar heater is a device that converts sunlight into heat energy and this heat energy is utilized in cooking food. The diagram of a box-type solar cooker is shown in Fig. 1.4. The body of a solar heater is generally made of metal or wood having suitable dimensions. Inside the box, aluminium sheets are used to serve as inner cooking box. These aluminium sheets are

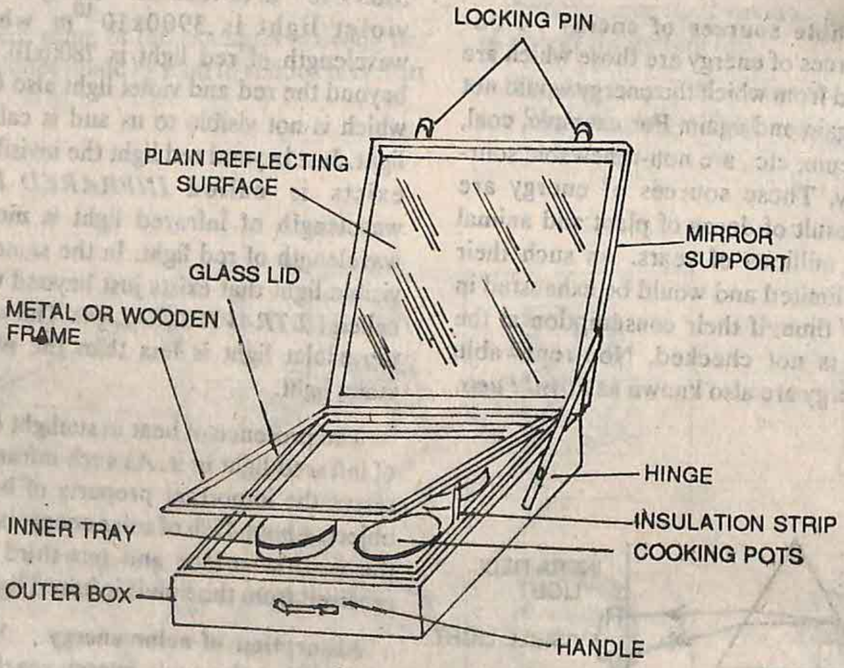

Fig. 1.4 Box-type solar cooker

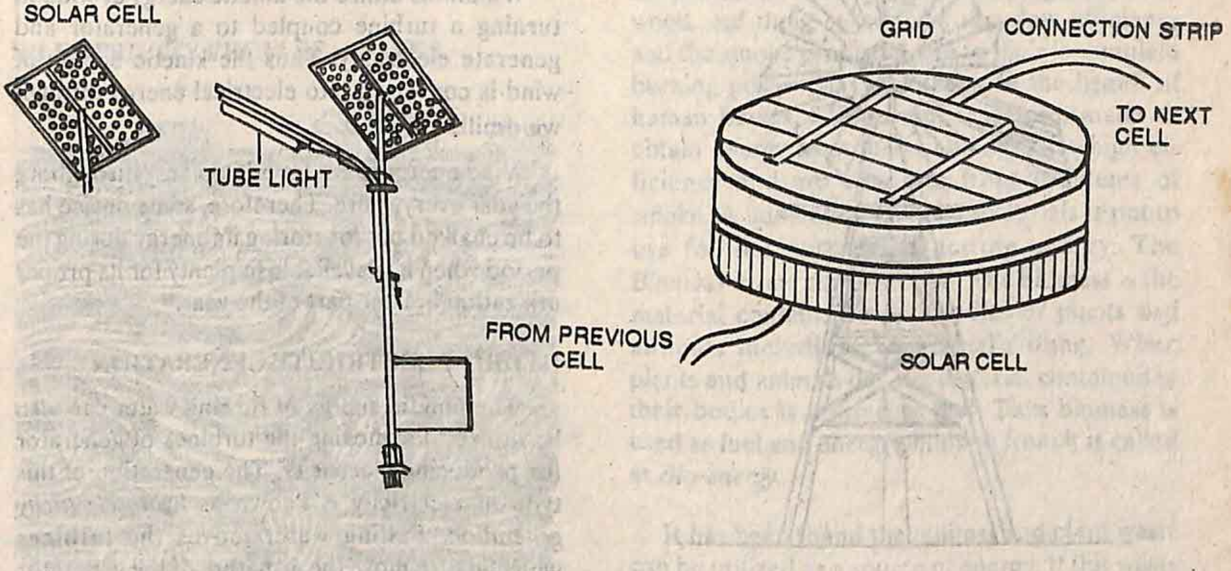

Fig. 1.5 A solar cell

painted black so that solar radiation may be absorbed. The lid of this solar heater is made of double glass sheets having a small space between them. The air inside this space acts as an insulator. The sun's energy enters inside the box through transparent glass but its infrared radiation cannot come out from the glass lid producing the heating effect inside the solar heater. Glass lid helps us in keeping the infrared radiation of the sun inside the box and blocks it in coming out. To increase the efficiency of the heater the mirrors are also used inside the box. So that the heat energy may be reflected towards the black absorber used inside it. To prevent heat losses, thermal insulators are used between inner and outer space of the solar heater. The cooking pots placed inside the solar heater is also made of aluminium or stainless steel. The outer surface of these pots are also painted black so that heat may be absorbed by them.

Under solar energy utilization programme, family solar heaters have been given wide publicity. Standard specifications have been laid down to protect consumers' interests so that spare parts of solar heater can be made readily available.

Solar Cells : Another important device for making use of solar energy is called solar cell (Fig. 1.5). The basic principle of solar cells is to convert light energy of the sun into electric current. It has been found that there are some materials which are neither good conductors nor good insulators, like germanium and silicon. If phosphorus or boron is added to them as an impurity, their conductivity increases manifold. If boron is added to silicon or germanium, these develop the affinity to attract electron and are known as p-type semiconductors. If phosphorus is added to silicon or germanium, electrons become surplus and it is termed as n-type semiconductor. *The thin sandwiches of p-n type semiconductors are known as solar cells.* For producing electricity for commercial purposes, many such solar cells are joined together to produce significant amount of electrical energy to be utilized for street lighting and other purposes.

Moving objects have kinetic energy with them. Due to differential heating of the atmosphere by

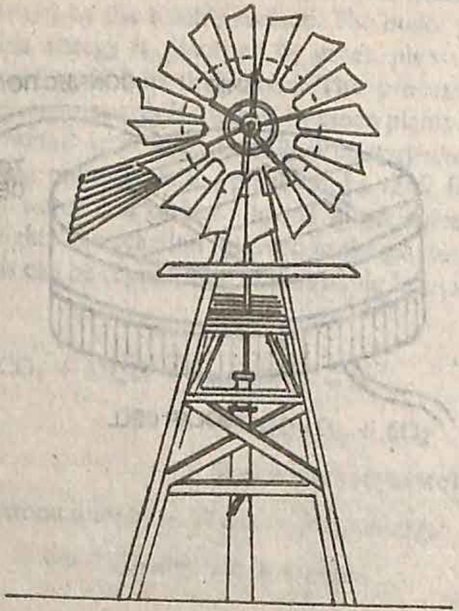

Fig. 1.6 Windmill

he sun, a movement of air takes place and is called wind. On account of its motion, wind has kinetic energy with it which can be utilized in performing work through *windmills*.

WINDMILLS

Windmills utilize the kinetic energy of wind in turning a turbine coupled to a generator and generate electricity. Thus the kinetic energy of wind is converted into electrical energy through windmills.

Wind energy is not found in plenty throughout the year everywhere. Therefore, some device has to be chalked out for storing its energy during the period when it is available in plenty for its proper utilization in later part of the year.

HYDRO-ELECTRICITY GENERATION

The kinetic energy of flowing water can also be utilized for moving the turbines of generator for producing electricity. The generation of this type of electricity is known as *hydro-electricity generation*. Falling water moves the turbines which in turn move the armature of the generator in the magnetic field producing electrical energy (*Fig. 1.7*)

As a matter of fact, the energy of naturally flowing water is trapped as potential energy in dams. Water is then made to fall on turbines to

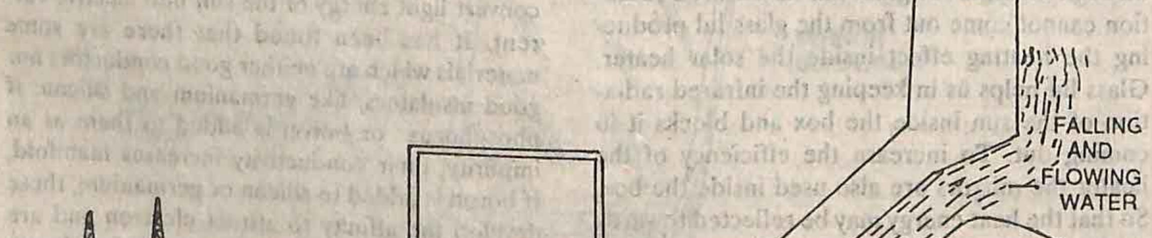

Fig. 1.7 Use of falling and flowing water in generating electrical energy

rotate them. The rotating turbines in turn rotate the armature of the generator to produce hydroelectricity.

ELECTRICITY FROM SEA-WAVES

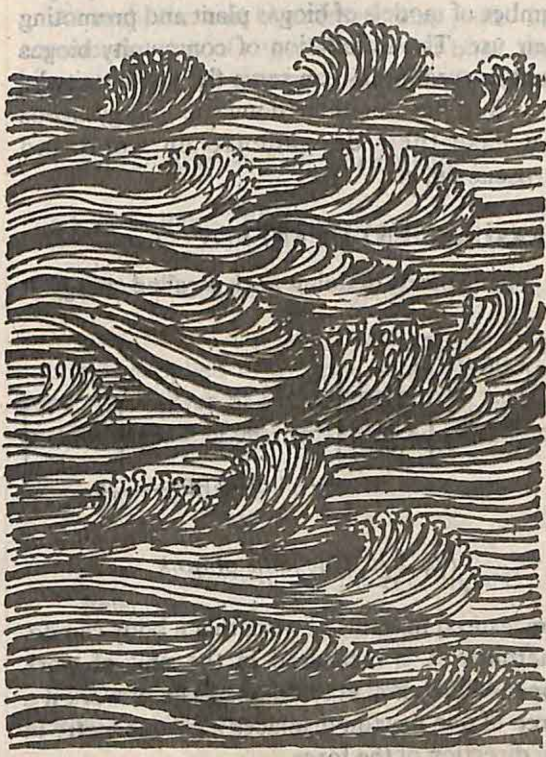

Fig. 1.8 Sea-waves for harnessing energy for future.

The rise and fall of water in the form of sea-waves can also cause motion in the armature of generator and thus produce electricity (*Fig. 1.8*).

The main problem, however, that still remains to be solved is to develop proper devices for harnessing the energy of sea-waves for producing electricity for future.

BIO-ENERGY

Man is always in search of different energy sources for multifarious activities. For cooking food man requires fire. The fire is obtained by burning various materials. Most of the energy required for domestic cooking purposes in rural areas is obtained from wood and dung cakes. The wood and dung cakes have very low efficiency and the smoke produced due to their incomplete burning poses many problems for the health of human beings. Efforts are, therefore, made to obtain energy from materials that have high efficiency and are also free from problems of smoke. A number of different materials is put to use for the purpose of getting energy. The *Biomass* is one such material. The biomass is the material contained in the bodies of plants and animals including the animal's dung. When plants and animals die, the material contained in their bodies is utilized as fuel. Thus biomass is used as fuel and energy obtained from it is called as *Bio-energy*.

It has been found that animal and plant waste can be utilized as a source of energy. If this waste is degraded by micro-organisms in the presence of water, a gas, which is a mixture of methane, carbon dioxide, hydrogen and hydrogen sulphide, is produced and is a very good fuel for domestic use. This gas is called *Biogas*. It burns almost without any smoke and has no injurious effects on health. Biogas plant is commonly used nowadays to produce Biogas. There are generally two common designs of biogas plants which are in use in our country. These are (i) the fixed-dome type and (ii) the floating gas-holder type.

The model of both type of gas plants are shown in Fig.1.9(a) and Fig.1.9(b). The essential parts of both types of gas plants are:

1. An inlet for dung and water mixture.

2. A digester where animal and plant wastes are degraded by anaerobic micro-organisms in the presence of water to produce biogas.

3. Gas holder with gas control arrangement for collecting and distributing gas through pipes.

4. An outlet for carrying out remaining slurry.

The slurry left in the Biogas plant is taken out through the outlet. This slurry serves as very

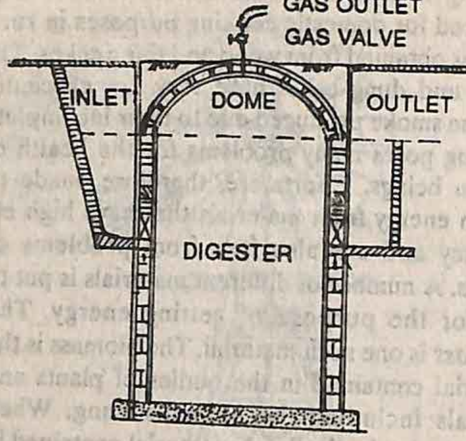

Fig. 1.9 (a) Fixed dome-type biogas plant

good manure as it contains rich amounts of phosphorus and nitrogenous compounds. It is used in the field by the farmer.

Biogas technology is now becoming increasingly popular among nations. Besides giving energy in the form of biogas, which is considered very good domestic fuel, it is also helping in controlling pollution and in providing manure in the form of slurry (left-out wastes of biogas plants). Animal dung and other wastes which contain several harmful micro-organisms and can cause diseases are used up in biogas plant. It helps in controlling pollution to a great extent. In India, Khadi and Village Industries Commission (KVIC) and other agencies are developing a number of models of biogas plant and promoting their use. The installation of community biogas plant in rural areas can serve the community by providing fuel for their domestic energy needs and ease their dependence on wood and kerosene oil, etc.

MEASUREMENT OF ENERGY

The capacity of doing work is called energy. It is measured in terms of work that a body can do. Therefore it is measured in the unit of work done. A body is said to do one joule of work if a force of one newton displaces it by one metre in the direction of the force.

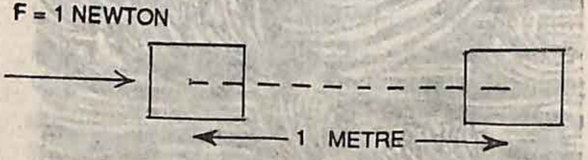

Fig. 1.10 One joule of work

$$W = F \times d$$

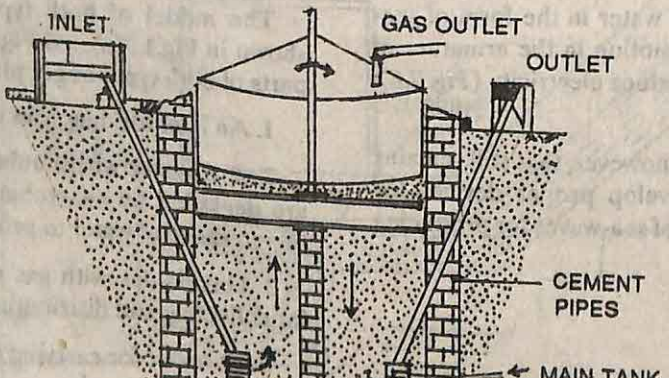

Fig. 1.9 (b) Floating gas holder-type biogas plant

$$= 1 \text{ newton} \times 1 \text{ metre}$$
$$= 1 \text{ newton metre}$$
$$= 1 \text{ joule}$$

As such, the unit of energy is also joule. The commercial unit of energy is kilowatt hour. One kilowatt hour of energy is equal to 3600000 joules.

$$1 \text{ kilowatt hour} = 1000 \text{ watt} \times 1 \text{ hour}$$

$$1 \text{ kwh} = 1000 \frac{joule}{sec} \times 60 \times 60 \text{ sec}$$

$$3600000 \text{ joule } (1 \text{ watt} = 1 \text{ joule} / 1 \text{ sec})$$

Watt is the unit of power. It is the rate at which energy is supplied or the rate at which work is done. The power of a source is said to be one watt if one joule of energy is supplied in one sec.

$$1 \text{ watt} = \frac{1 joule}{1 sec}$$

$$\text{Power} = \frac{\text{Work done / Energy supplied}}{\text{Time taken}}$$

The bigger unit of power is kilowatt. 1 kilowatt is equal to 1000 watts.

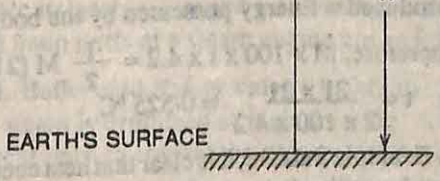

Fig. 1.11 (a) Potential energy of a body at a height h from the earth's surface

The energy possessed by a body on account of its position is called its potential energy. Water stored in a dam possesses potential energy. A body of mass 0.1 kg possesses potential energy of approx. 1 joule if it is placed at a height of 1 metre from the earth's surface.

The potential energy of a body of mass m kg and at a height of h metre from the earth's surface is given as

$$\boxed{\text{P.E.} = m \times g \times h}$$

where g is the acceleration due to gravity. It is equal to 9.8 m/sec^2. Similarly, the energy possessed by a body on account of its motion is called its kinetic energy. If a body of mass m is moving with a velocity v, the kinetic energy possessed by it is given by $\frac{1}{2} mv^2$, i.e.,

$$\boxed{\text{K.E.} = \tfrac{1}{2} mv^2}$$

The energy can be transformed from one form to another or can be transformed from one body to another. It can neither be produced nor destroyed. This is known as the *principle of conservation of energy.*

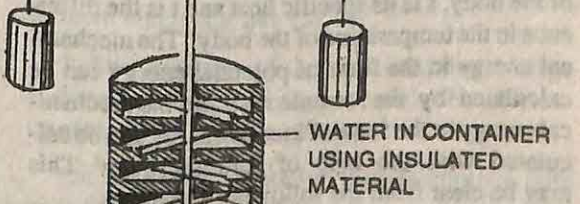

Fig. 1.11 (b) Joule's experiment for measuring the mechanical equivalent of heat

Diesel engine : In the diesel engine there are no sparking plugs. On the compression stroke the fuel air mixture is compressed so much that it heats up a great deal and catches fire on its own without the need for a spark. Diesel engines are very reliable and have higher efficiency than petrol-driven internal combustion engines.

Question : A steam engine has 30% efficiency. If the steam in the engine has 1000 j of energy how high would this engine lift a weight of 1 kg from the ground.

(The value of 'g' may be taken as 10 m/sec^2)

Ans. : As the efficiency of engine is 30%, the amount of energy used up for useful work done will be

$$\text{30\% of 1000 joules} = \frac{30}{100} \times 1000$$

$$= 300 \text{ joules}$$

Thus, 300 joules of energy is used up in lifting the weight of 1 kg from the ground. Let the stone be lifted to a height of h metres from the ground. The amount of energy required in lifting it to this height will be $1 \times g \times h = 1 \times 10 \times h$ joules.

Therefore, $1 \times 10 \times h = 300$

or $h = 30$ metres.

SUMMARY

1. Renewable sources of energy are those from which we can get energy again and again, such as sun, wind, animal wastes, etc.
2. Non-renewable sources of energy are those from which energy would not be available again and again, such as coal, petroleum etc.
3. Energy that we get from the Sun is called solar energy.
4. The invisible light that exists just beyond the red light is called infra red light. Its wavelength is more than that of red light.
5. The invisible light that exists just beyond the violet light is called ultra violet light. Its wavelength is less than that of violet light.
6. The process by which solar energy is trapped by green plants and converted into food is called photosynthesis.
7. The heating effect inside the solar heater is produced due to infrared radiation of the Sun.
8. The sandwitches of p-n type semiconductors are known as *solar cells.*
9. Windmills utilize the kinetic energy of the wind.
10. The hydroelectric generator utilizes the kinetic energy of the flowing water.
11. The energy obtained from animal and plant waste is known as Bio-energy.
12. Biogas plant is used to produce biogas which is a very good fuel for domestic use and burns without any smoke. It contains mainly methane.
13. The slurry left in a biogas plant serves the purpose of good manure.
14. The energy is measured in the unit of work done and is called joule.
15. Kilowatt hour is also a unit of energy.

1 kilowatt hour = 3600000 joules.

16. P.E. = mgh and K.E. = $1/2\ mv^2$
17. 1 cal = 4.2 joules
18. The rate of doing the work is called power. Its unit is watt.
19. The devices which can convert heat energy into mechanical energy are called Heat Engines.
20. The efficiency of an engine is written as
    efficiency in % = (Useful work done / Energy given) x 100.
21. Heat engines are of two types (1) External Combustion Engine, like steam engine. (2) Internal Combustion Engine, like petrol and diesel engines.
22. The internal combustion engine has the advantage of having better efficiency, and of being safer and smaller, too, in size as compared to steam engine.
23. The working principle of an internal combustion engine consists of four strokes :
    (A) INTAKE STROKE (B) COMPRESSION STROKE (C) POWER STROKE (D) EXHAUST STROKE.
24. Petrol engine uses carburettor and spark plug whereas diesel engine does not use these.

QUESTIONS

Very Short Answer Type Questions

1. Flowing water can rotate a turbine. Which type of energy is used up by the turbine?
2. Which part of invisible light of the Sun is used in solar heater for cooking?
3. What kind of energy is used in windmills?
4. What is the range of visible light of the Sun?
5. Name the invisible light of the Sun having the wavelength more than red light.
6. Name the invisible light of the Sun having the wavelength less than violet light.
7. Name any two devices by which the solar energy is used.
8. What is the name of the process by which plants prepare their food in presence of Sunlight?
9. What is the S. I. unit of energy?
10. What type of energy is converted into electricity at the hydroelectric power station?
11. How much energy will be required if a force of one newton displaces an object by one metre?
12. Name the gas present in Biogas other than carbon dioxide, hydrogen, hydrogen sulphide.
13. Name two devices which use solar energy.
14. What is the use of slurry left in a Biogas plant? Give the reason for its use.
15. How much water will be required so that the entire 4.2 kj energy may raise the temperature of water by 1°C. (The sp. heat of water is 4200 j/ °C/kg).
16. The power of an internal combustion engine is 1000 watts. How much energy will it supply in an hour?

Heat energy and mechanical energy : It is our common experience that when some mechanical work is done, heat is produced. For example, when we rub our hands, hands become warmer.

Similarly, when air is pumped into the cycle tube the barrel of the pump is heated up. When hammer is raised and made to fall on the head of a nail number of times, the nail is heated up. The potential energy of the hammer is converted first into kinetic energy and then into heat energy. The British scientist Dr. Joule performed a number of experiments to establish a relation between the mechanical work done and heat produced. He found that in order to raise the temperature of 1 g of water through 1°C, about 4.2 joules of mechanical work is to be performed or in other words we can say that 4.2 joules of mechanical work is equivalent to 1 calorie of heat. This is known as mechanical equivalent of Heat (J). Thus, mechanical equivalent of heat is that amount of mechanical work which is required to produce 1 cal. of heat. Its value is 4.2 joules/cal. It shows how joules and calories are related.

The arrangement of Joule's experiment for measuring the mechanical equivalent of Heat (J) is shown in Fig 1.11 (b). Here, the falling weights lose potential energy and the paddles connected to these gain kinetic energy, which stirs the matter in the container, raising its temperature. By carefully performing the experiment, Joule concluded that when the falling weights lost about 4200 joule energy, the temperature of 1 kg of water went up by 1 °C.

$$1 \text{ cal} = 4.2 \text{ joules}$$

Heat given or taken by a body is calculated by the formula $\boxed{H = m \times s \times t}$ where m is the mass of the body, s is its specific heat and t is the difference in the temperature of the body. The mechanical energy in the form of potential energy can be calculated by the formula mgh and the mechanical energy in the form of kinetic energy can be calculated with the help of formula $\frac{1}{2} mv^2$. This may be clear from the following examples.

Example 1: What will be the temp. difference of water at the top and at the bottom of a water fall of 420 metres high, supposing that whole energy of water is converted into heat.

(Specific heat of water = 4200 joules/kg/°C)

Solution : Let M kg be the mass of water falling and t is its temperature difference at top and bottom.

The energy of water (W) = M x g x h
= M x 9.8 x 420 joules

The heat produced, H = M x s x t
= M x 4200 x t joules

As the energy of water is converted into heat
M x 9.8 x 420 = M x 4200 x t
or t = (9.8 x 420)/4200 = 0.98 °C

Example 2 : 10 cal. heat of some water is fully utilized in raising a stone of mass 1 kg. Calculate the height to which it can be raised. (g may be taken as 10 m/sec²).

Solution : Heat possessed by the water
= 10 calories
= 10 x 4.2 joules

Let the stone be raised through a height h metres. The energy required to raise the stone of mass 1 kg = 1 x 10 x h joules.

Therefore, 1 x 10 x h = 10 x 4.2
or h = 4.2 metres

Example 3 : A body moving with a velocity of 21 m/sec strikes a wall and is stopped. If the energy of the body is used up in producing heat inside the body, find out the rise in its temperature (specific heat of the body = 100cal/kg/°C

Let the amss of the body be M kg and rise in its temperature t.

The energy possessed by the body = $\frac{1}{2} MV^2$
= $\frac{1}{2} M (21)^2$ joules

The heat produced = M x s x t
= M x 100 x t cal
= M x 100 x t x 4.2 joules

Heat produced = Energy possessed by the body

Therefore, M x 100 x t x 4.2 = $\frac{1}{2} M (21)^2$

or $t = \frac{21 \times 21}{2 \times 100 \times 4.2} = 0{\cdot}525\ °C$

In Example 2 above, it is clear that heat energy can also be utilized in performing mechanical work. As a matter of fact, one calorie of heat should do 4·2 joules of mechanical work (1 cal = 4·2 joules). But so far no device has been developed which can convert the whole of the heat energy into mechanical work. A lot of heat energy is used up in overcoming the frictional and other forces of such devices and only some percentage of heat energy is converted into useful mechanical work. The ratio of the useful work done to the total energy given to the device is known as its efficiency. Therefore, efficiency of a device

$$= \frac{\text{Useful work done}}{\text{Energy given}}$$

This efficiency is generally represented in percentage as

$$\text{Efficiency in \%} = \frac{\text{Useful work done}}{\text{Energy given}} \times 100$$

The efficiency of any device converting heat energy into mechanical work is never cent per cent.

The devices which can convert heat energy into mechanical energy are called Heat Engines.

Heat engines are of following two types :

1. External Combustion Engine
2. Internal Combustion Engine

EXTERNAL COMBUSTION ENGINE

Steam engine is an example of external combustion engine. It was first invented by James Watt. In the external combustion engine, combustion takes place outside the cylinder. The fuel is burnt and water is heated up to form steam. This steam is then taken inside the cylinder where its heat is changed into mechanical work. The main parts of a steam engine are as follows :

1. Boiler and Safety Valve : Inside the boiler the steam is produced at high pressure. A safety valve is used to control the pressure of the steam.

2. Steam Chest : It is a strong box in which comes steam from the boiler. It consists of D shaped valve which makes movement inside it. It also has three openings. Steam from boiler enters the steam chest from one of the openings which connects it to the boiler. Steam enters the cylinder from these openings and in turn comes out from outlet.

3. Cylinder : Inside the cylinder the piston makes forward and backward movement on account of the heat energy of the steam.

4. Piston : Piston makes forward and backward movement inside the cylinder. It is connected to the shaft with the piston and connecting rods.

5. Crank : It is in the shaft which is joined with the connecting rod. It helps in converting the to and fro motion of the piston into the rotatory motion of the shaft.

6. Speed Governor : It controls the amount of steam from entering into the cylinder from the boiler, so that engine can move with a constant speed.

7. Flywheel: A heavywheel is connected to the shaft and rotates along with it.

The working of a steam engine along with all its parts is shown in Fig. 1-12.

The external combustion engine has the following limitations on account of which it cannot be used for different purposes :

1. Steam is kept at a high pressure so there is always the danger of bursting the boiler.

2. Steam is produced by boiling the water which requires burning of the fuel and a good amount of water and on this account the size of boiler becomes bulky. As such it cannot be used in small machines, like car, etc.

3. The large size of the boiler exposes a large surface for the loss of heat. As such, the efficiency of such engines is very low.

On account of these limitations another type of engine was designed and built in which these limitations were overcome. This type of engine is known as Internal Combustion Engine.

Strictly according to the latest syllabus prescribed by the Central Board of Secondary Education, New Delhi in Science for Class X of Secondary School Certificate Examination under the Delhi and All India Schemes.

FUNDAMENTALS
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Vol. II Part I

Covering UNIT I (Energy) and UNIT V (Universe)

(For Class X)

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INTERNAL COMBUSTION ENGINE

Internal Combustion Engine was invented by Rudolph Diesel and Nikolaus Otto. In this engine the combustion takes place inside the cylinder. On the basis of the fuel used in these, they are classified in two types :

(1) Petrol Engine, and

(2) Diesel Engine.

The working of an Internal Combustion Engine is shown in the diagrams (Figs. 1.13 – 1.16). Its working consists of four strokes :

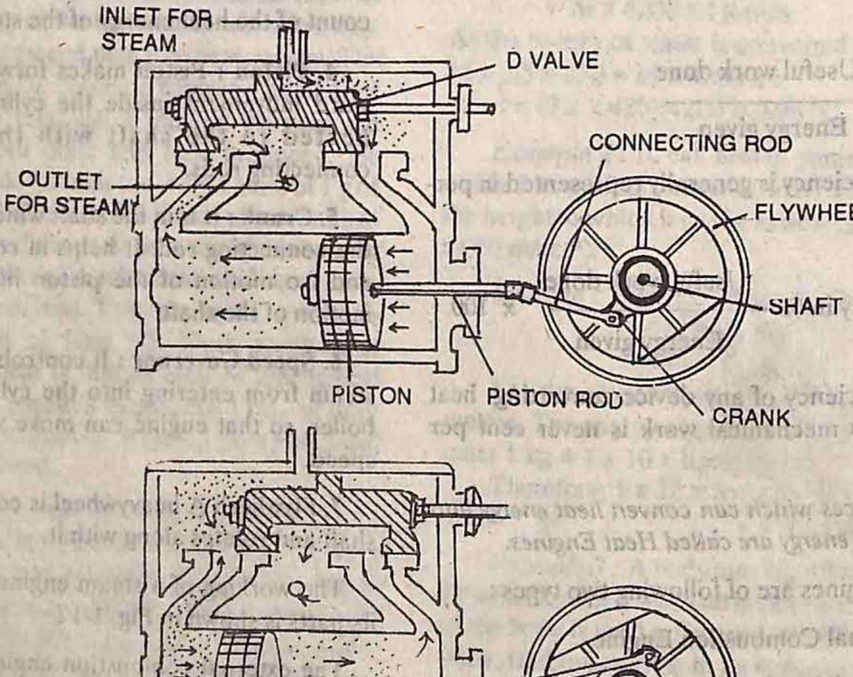

Fig. 1.12 Working of a steam engine—External Combustion Engine.

1. Intake Stroke : In this stroke, the piston moves downwards carried by the inertia of the flywheel, and the petrol air mixture is sucked into the cylinder through the open inlet valve. The outlet valve is closed.

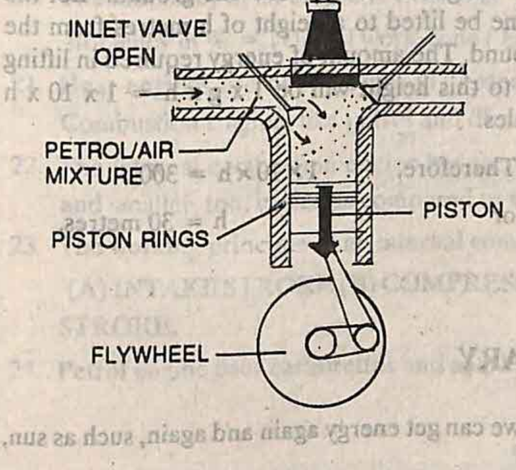

Fig. 1.13 Intake stroke (Internal Combustion Engine)

2. Compression Stroke : The flywheel moves round, pushing the piston up and compressing the mixture inside the cylinder. Both the valves are closed during this stroke.

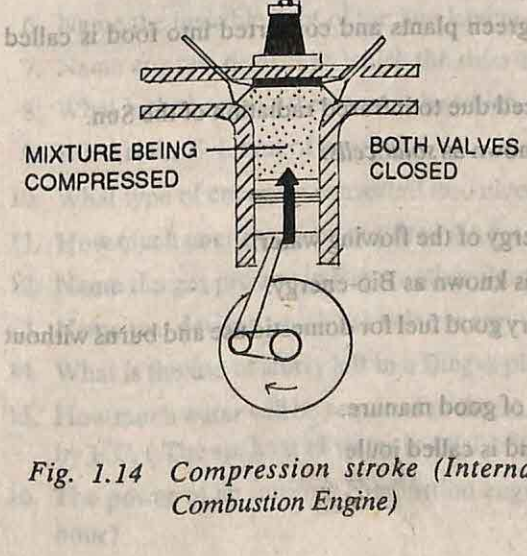

Fig. 1.14 Compression stroke (Internal Combustion Engine)

3. Power Stroke : When the piston reaches its highest position the spark plug fires and ignition takes place. When it is ignited it generates heat and the gas of petrol-air mixture expands which in turn forces the piston to move downwards. Both valves are closed during this stroke.

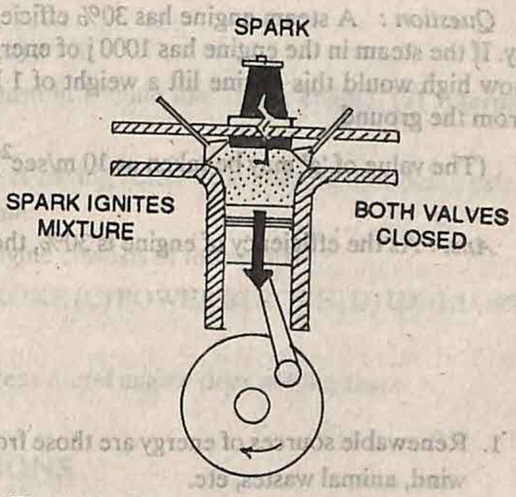

Fig. 1-15 : Power stroke (Internal Combustion Engine)

4. Exhaust Stroke : As the piston moves up again the burnt gases are forced out of the open exhaust valve. The inlet valve stays shut.

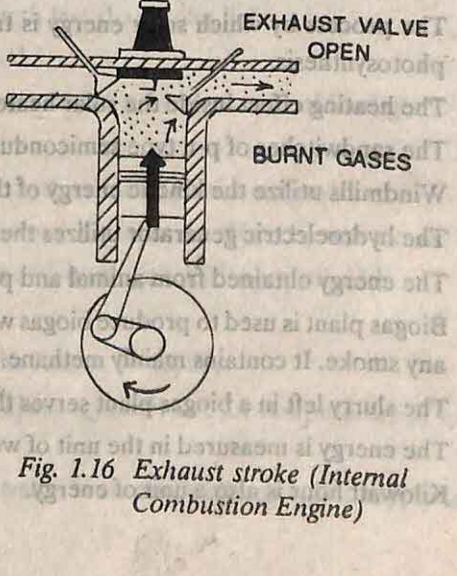

Fig. 1.16 Exhaust stroke (Internal Combustion Engine)

17. 1 g fuel on burning provides 86 kilo joule energy. How much fuel will be required to get 1 kwh energy?

Short Answer Type Questions

1. Differentiate between renewable and non-renewable sources of energy.
2. Explain the composition of sunlight.
3. How will you differentiate between ultraviolet light and infrared light?
4. Define potential energy. Give its unit.
5. Water is falling on the blades of a turbine at the rate of $6x10^2$ kg per minute. The height of the fall is 100m. Find the power delivered to the turbine (use $g = 10 \text{ m/sec}^2$).
6. In which form would you like to convert cowdung to get maximum advantage? Write three such advantages.
7. What is Bio-energy?
8. Convert 1 kilowatt energy into joules.
9. How much water will be required so that the entire 4.2 kj energy may raise the temperature of water by 1 °C? (The sp. heat of water is 4200 j per °C per kg).
10. What is power?

    The power of an electric bulb is 100 watts. How much energy will it supply in an hour?
11. What are p and n- type conductors?
12. What are the reasons that biogas technology is becoming increasingly popular among nations?
13. Define 'Power'. Mention its unit.
14. An engine is designed to convert 40% of heat energy into work. If the steam in the engine has 5000j of energy, how high would this engine lift a weight of 10 kg from the ground? (Given $g = 10 \text{ m/sec}^2$).
15. 42 kj energy is supplied to 1 kg of water. If 50% of this energy is converted into heat to raise its temperature, calculate the rise in the temperature of water (sp. heat of water is 4200 j per kg per°C.)
16. An engine supplies 30,6000 j energy in an hour. What is its power?
17. If an engine can lift a body to a height of 100 metres by using 1.96 kj heat energy. Find the efficiency of the engine ($g = 9.8 \text{ m/sec}^2$)
18. The reading of an electric metre in your house indicates 90 units (kwh) consumption at the end of a month. If two 100 watt bulbs for 10 hours are used daily besides using an immersion rod for half an hour daily. Find out, how many watts were used in the immersion rod.
19. Give two advantages of internal combustion engine over external combustion engine.
20. Mention any two limitations of steam engine.
21. Why is biogas considered as good fuel for domestic use?

Essay Type Questions

1. What are solar cells? Explain the working of a solar cell.
2. Explain the functioning of a solar heater.
3. Mention essential parts of a Biogas plant by drawing its labelled diagram.
4. With the help of a diagram, explain the construction of internal combustion engine. Give its two advantages over an external combustion engine.
5. With the help of a diagram, explain the construction of an external combustion engine. Give any two limitations of an external combustion engine over an internal combustion engine.

Chapter 2

FUELS

LEARNING OBJECTIVES

1. To know different kinds of Fossil Fuels, such as coal, petroleum and natural gas etc.
2. To enlist various products obtained during the process of heating coal in the absence of air, i.e., during the process of its destructive distillation.
3. To know about the occurrence and composition of petroleum.
4. To understand the process of fractional distillation of petroleum and to know about the useful products obtained therein.
5. To know about the composition and use of natural gas.
6. To know about the rocket fuel and classification of different kinds of fuels.
7. To understand the calorific value of fuels and its measurement and to apply this knowledge in simple numerical questions.
8. To understand the ignition temperature and its importance.
9. To know about combustion, its types and conditions for combustion and its application for food in living organism.
10. To enlist various factors responsible for ideal fuel.

INTRODUCTION

Substances which on burning provide heat energy are called *fuels.* Fuels play a very important part in our day-to-day requirements of energy. For cooking our food, we require heat energy which is obtained by burning different kinds of fuels. Wood is very common fuel used for cooking food. In many houses, especially in rural areas, wood is burnt in traditional chullahs. The incomplete combustion of wood produces smoke which is harmful for health. An improvement in the traditional chullahs has been made at some places to provide smokeless chullahs which have a chimney attached for letting out the smoke.

Later on, man has learnt to make charcoal to use it as fuel. Charcoal is made by the destructive distillation of wood. In this process wood is burnt in insufficient supply of air. The charcoal is mainly carbon. The diagram for destructive distillation of wood for producing charcoal is shown in Fig. 2.1.

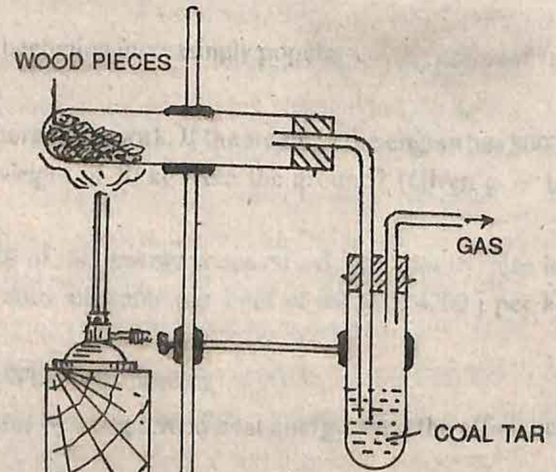

Fig. 2.1 Destructive distillation of wood

The residue which is left in the test tube by the burning of wood in insufficient supply of air is charcoal. It is found that 1 gram charcoal on burning gives about 33 kilo joules energy whereas 1 gram wood on burning gives about 17 kilo joules energy. As such charcoal is considered a better fuel than wood. Secondly charcoal also burns without any smoke.

We find that animal dung cakes are also used in many houses for producing heat for cooking purposes, etc. Insufficient burning of animal dung cakes produces a lot of smoke and also destroys the nutrients present in it. As such, it is not advisable to use animal dung cakes as fuel.

In the last chapter, we have studied that animal dung is used in *Biogas plant for producing Bio-gas,* which is considered as a good fuel for domestic purpose. The working of a Biogas plant and the advantage of using Biogas have already been discussed in that chapter.

Fuels, so far discussed, are renewable sources of energy. In this chapter we will discuss mainly those fuels which are considered as non-renewable sources of energy, such as fossil fuels.

FOSSIL FUELS

Fossil fuels are non-renewable sources of energy. Coal, petroleum and natural gas are examples of fossil fuels. These fossil fuels are formed in millions of years, due to the slow decomposition of the remains of plants and animals inside the earth at high temperature and pressure. In case these fossil fuels are used up at a rate faster than the earth can recreate them, these will be finished in a matter of time.

Table 2.1

Type of coal	Percentage of carbon	Percentage of moisture
1. Lignite	38 %	43 %
2. Bituminous	65 %	4 %
3. Anthracite	96 %	3 %

Coal : Coal is one form of fossil fuels. It is formed from the decomposition of remains of trees and plants, etc., inside the earth at high temperature and pressure for a number of years.

Coal is made of the atoms of carbon, hydrogen and oxygen. It also consists of some amount of sulphur along with water in the form of moisture. In India coal mines are working mainly in Bihar, Madhya Pradesh and West Bengal to extract the coal deposits inside the earth. On account of the variation of carbon contents in coal, it is classified mainly in three types, namely, (1) Lignite Coal, (2) Bituminous Coal and (3) Anthracite Coal. The percentage of carbon and moisture contents in these three varieties of coal are shown in the table given above.

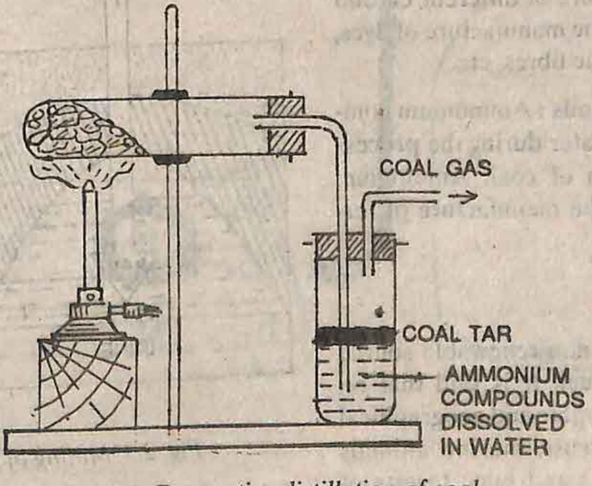

Fig. 2.2 Destructive distillation of coal

Lignite, Bituminous and Anthracite Coal are also known as Brown Coal, Soft Coal and Hard Coal respectively. The energy value of coal is determined by content of carbon in it. More is the carbon content in it more will be its energy value.

DESTRUCTIVE DISTILLATION OF COAL

The process of heating coal in the absence of air is called destructive distillation of coal. The process of destructive distillation of coal is shown in Fig. 2-2.

The products that are obtained during the process of destructive distillation are (1) Coke, (2) Coal gas, (3) Coal Tar and (4) Ammonium Compounds.

1. Coke : The residue which is left out in the tube after destructive distillation is called coke. It is a good fuel and burns without smoke. It is used as a reducing agent in the extraction of iron from its ore. It is also used for making water gas and for manufacturing calcium carbide.

2. Coal gas : It is a mixture of hydrogen, carbon monoxide and methane. Coal gas is a good fuel. During destructive distillation of coal it comes out from the side tube of the vertical test tube. It is used as fuel and for the manufacture of plastics.

3. Coal tar : Coal tar condenses and floats at the surface of water during the destructive distillation of coal. It is a mixture of different carbon compounds. It is used in the manufacture of dyes, paints, explosives, synthetic fibres, etc.

4. Ammonium compounds : Ammonium compounds are dissolved in water during the process of destructive distillation of coal. Ammonium compounds are used in the manufacture of fertilizers.

PETROLEUM

Petroleum is another non-renewable source of energy. It is a fossil fuel. It is said that on account of various catastrophic and geographical changes in the earth's crust, marine animals (animals living in the sea) and huge forests of plants in the remote past got buried into the earth where, during ages, by the action of high pressure and temperature and under the influence of bacteria or radioactive substances, they got practically decomposed and gave rise to petroleum.

Composition of petroleum : Petroleum is a complex mixture of hydrocarbons together with small quantities of organic compounds containing oxygen, nitrogen and sulphur. It is a viscous, coloured (light green to almost black) liquid called *crude oil* or *crude.* Since it is a mixture, its composition varies considerably with the place of origin. For example, Assam oil contains mainly paraffin whereas Russian oil contains large percentage of benzene, toluene, naphthalene, etc.

Occurrence of petroleum : Petroleum alongwith natural gas and saltwater, usually occurs underneath the surface of the earth at different depths at different places. The oil is found in porous strata beneath the impervious rock.

Mining of petroleum : The crude oil is mined by drilling wells through the impervious rock layers to the oil bearing rocks or sands. The pressure of the natural gas forces the crude oil to the surface of the earth. When the pressure is released, crude oil is pumped out and is carried

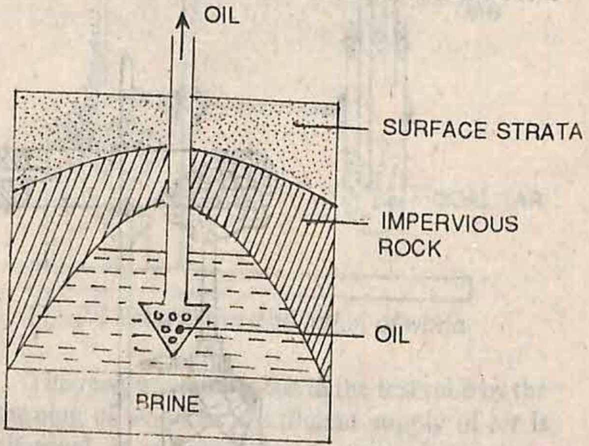

Fig. 2.3 Mining of petroleum

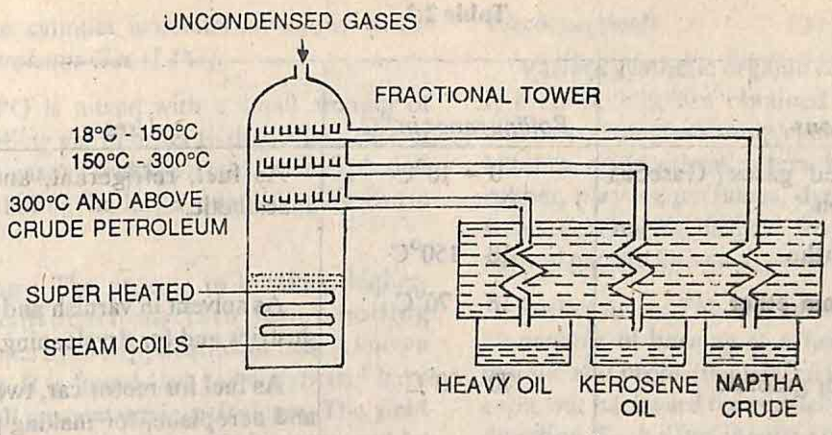

Fig. 2.4 Fractional distillation of petroleum

to the refinery through underground pipes for refining.

Refining of petroleum : The different components of crude oil have distinctly different boiling points. This fact is utilized in separating them into useful fractions by fractional distillation. The process of separation of various fractions is known as *refining of petroleum.* In the refinery, crude oil is heated to 400°C by which most of the oil is evaporated. These vapours are passed in a tall fractionating column where high-boiling fractions condense, first near the bottom of the column and low-boiling fractions condense last near the top. The uncondensed gases escape

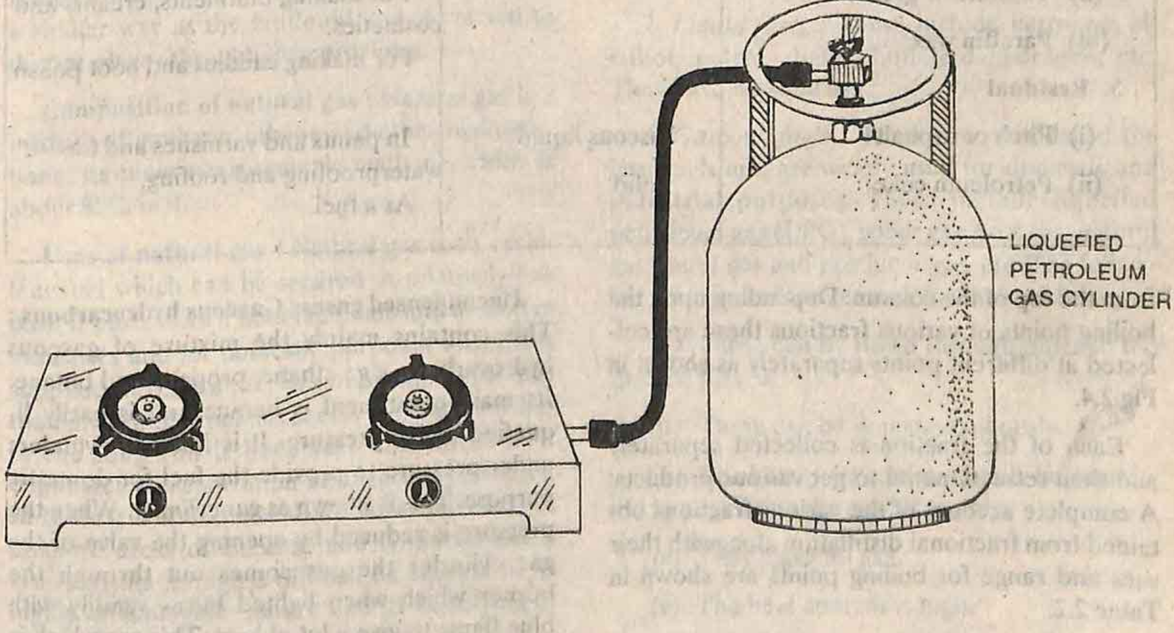

Fig. 2.5 Use of Liquefied Petroleum Gas (in cylinder)

Table 2.2

Fractions	*Boiling range in °C*	*Uses*
1. Uncondensed gases / Gaseous hydrocarbon	0 – 18°C	As fuel, refrigerant, and as local anaesthetic.
2. **Crude Naphtha**	18 – 150°C	
(i) Petroleum ether	18 – 70°C	As solvent in varnish and rubber industries and for drycleaning.
(ii) Petrol or gasoline	70 – 90°C	As fuel for motor car, two-wheeler, and aeroplane, for making petrol gas, for drycleaning.
(iii) Light petroleum	90 – 120°C	As solvent and for drycleaning.
(iv) Benzene	120 – 150°C	In varnish and for drycleaning.
3. **Kerosene or Paraffin oil**		
(i) Kerosene	150 – 300°C	As domestic fuel and for making oil gas. Used in wick stove, hurricane lamp, petromax lamp, etc.
(ii) Fuel oil (Diesel oil)	300 – 350°C	As a fuel oil for diesel engines.
4. **Heavy oil or Gas oil**	Above 350°C	
(i) Lubricating oil		As lubricants.
(ii) Vaseline or grease		For making ointments, creams and cosmetics.
(iii) Paraffin wax		For making candles and boot polish.
5. **Residual**		
(i) Pitch or asphalt	Viscous liquid	In paints and varnishes and for waterproofing and roofing.
(ii) Petroleum coke	Solid	As a fuel.

from the top of the column. Depending upon the boiling points of various fractions these are collected at different points separately as shown in Fig.2.4.

Each of the fraction is collected separately and then refractionated to get various products. A complete account of the various fractions obtained from fractional distillation alongwith their uses and range for boiling points are shown in Table 2.2.

Uncondensed gases / Gaseous hydrocarbons : This contains mainly the mixture of gaseous hydrocarbons, *e.g.*, ethane, propane and butane. Its main constituent is butane and is easily liquefied under pressure. It is filled in cylinders under pressure to provide the fuel for domestic purpose. This is known as *gas cylinder.* When the pressure is reduced by opening the valve of the gas cylinder the gas comes out through the burner which when lighted burns readily with blue flame to give a lot of heat. This gas which is filled in gas cylinder is commonly known as *Liquefied Petroleum Gas (LPG).*

This LPG is mixed with a small amount of strong smelling gas in order to detect it in case of leakage. In case of leakage it can cause explosion and its inhaling in large quantity may cause death.

Cracking : The process of breaking higher-boiling hydrocarbons into lower-boiling hydrocarbons by the application of heat is known as *cracking.* It is found that gasoline/petrol have only a small percentage in petroleum. The yield of petrol/gasoline may however be increased by the process of cracking. Sometimes the entire petroleum residue, after the removal of gasoline/petroleum fraction, is subjected to cracking to convert it into gasoline/petroleum.

You have seen that as a fractional distillation of petroleum we get a number of useful products; as such, it is called *black gold.*

Natural gas : Natural gas is also a form of fossil fuel. It is almost always present in petroleum wells and is obtained as byproduct from the petroleum wells. However, natural gas is also found separately. It is drilled from well in a similar way as the crude oil and is carried to distant places through long pipelines.

Composition of natural gas : Natural gas is a mixture of methane, ethane and other hydrocarbons. Its main constituent is methane which is about 85% in it.

Uses of natural gas : Natural gas is an excellent fuel which can be secured at relatively low cost. It burns with a hot blue flame and is used in industries and for domestic purposes where it is supplied through a network of pipelines. Initially the network of pipelines seems to be costlier but in the long run it becomes economical as it eliminates transportation and storing problems. In India it is found near Baroda, Tripura and in offshore areas of Bombay and Godavari delta. However, its storage is difficult on account of its highly inflammable nature and its liquefying at very low temperature.

Petrochemicals

Various synthetic organic compounds, directly or indirectly, are obtained from natural gas and petroleum, for example, alcohols, aldehydes, ketones, acids, ethers, esters, benzene, synthetic rubber, plastics, perfumes, dyes, etc. These substances/chemicals derived from petroleum and natural gas are known as *petrochemicals.*

Rocket fuels : The fuel used in rockets should be capable of burning at a fast rate, leaving no residue and producing a large volume of gases to come out backward for propelling it in a forward direction. Such a fuel is called *propellant.* Propellant contains fuel as well as oxidizer. The fuel may be liquid hydrogen, hydrogen and cellulose-based compounds, etc. It is mixed with the oxidizers like hydrogen peroxide, liquid oxygen, etc., in a suitable proportion.

Classifications of fuels

According to the states of the fuel, these can be classified in three classes.

1. *Solid fuels :* These include wood, coal, coke, charcoal, etc. These are derived from plants directly or indirectly.

2. *Liquid fuels :* These include kerosene, alcohol, petrol, diesel, liquefied hydrogen, etc. They have no solid ash.

3. *Gaseous fuels :* These are considered the best fuels and are widely used for domestic and industrial purposes. These include liquefied petroleum gas (LPG), *gobar* gas, coal gas, natural gas, water gas and producer gas, etc. The following are some of the reasons for their wide use:

(i) These can be flown through pipes to the desired places.

(ii) These can be lit instantaneously.

(iii) The heat produced can easily be controlled by regulating the gas/air supply.

(iv) They leave no ash.

(v) The heat content is high.

Another classification of fuels is based on its existence in nature or its manufacturing or processing. As such, the fuels are classified in two types :

(i) **Natural or raw fuels** : These include wood, coal, natural gas, petroleum, etc.

(ii) **Manufactured or processed fuels** : These include petrol, diesel, kerosene, water gas, etc.

Fuels are also classified as primary and secondary fuels.

Primary fuels : Primary fuels are those which are used directly to produce heat, for example, wood, coal and petroleum, etc.

Secondary fuels : Secondary fuels on the other hand are those fuels which are derived from primary fuels, for example, water gas, producer gas, coal gas, etc.

Table : 2.3

Fuel	*Calorific value in kilo joule/g*
Solid	
Dung cake	6-8
Wood	16-17
Charcoal	31-33
Liquid	
Fuel oil	43-45
Kerosene	48
Gases	
Biogas	35-40
LPG (Butane)	55
Methane	55.6
Hydrogen	150

CHARACTERISTICS OF FUELS

Calorific value of fuels

The heat energy liberated on burning different fuels is different. *The amount of heat energy liberated on burning unit mass of the fuel is called its calorific value.* As such, different fuels have different calorific values. For example, if the calorific value of a fuel is 55.6 kj/g it means that on burning 1 g of this fuel 55.6 kilo joule heat energy will be liberated. The more the calorific value of a fuel, the more heat energy will be obtained from it on its burning. In the table on the side, the calorific values of some solid, liquid and gaseous fuels are given to give you an idea of the type of fuel more useful from the point of view of its liberation of heat energy.

From the study of this table, it is clear that hydrogen gas has the highest calorific value. Inspite of its high calorific value hydrogen gas is not commonly used for domestic and industrial purposes because it cannot be handled safely.

Hydrogen is abundantly available on the earth as the main constituent of water. In case it can be handled safely, it may become the main source of energy for domestic and industrial purposes.

MEASUREMENT OF CALORIFIC VALUE OF A FUEL

The calorific value of a fuel can be known by calculating the amount of heat produced on burning of 1 g of fuel. The following activity can be performed for this purpose.

Activity : A known mass of fuel is burnt to provide heat to water kept in a calorimeter. The initial temperature of water and calorimeter is noted with the help of thermometer. Providing heat to water and calorimeter on account of the burning fuel will raise the temperature of water and calorimeter. By noting this temperature the rise in the temperature of water and calorimeter can be known. Heat energy taken by water and calorimeter can be calculated with the help of formula MSt separately and then summing them up to get the total amount of heat energy taken by both water and calorimeter (M is the mass, S is the sp. heat and t is rise in temperature). Supposing that the total heat energy liberated by the burning of the fuel was taken by water and calorimeter, the total amount of heat produced on burning the fuel can be calculated. If this amount of heat so calculated is divided by the mass of fuel burnt we can get the calorific value of the fuel. It can be summarized as follows :

$$\begin{aligned} \text{Heat produced by burning m mass of fuel} &= \text{Heat taken by water} + \text{Heat taken by calorimeter} \\ &= M_1 S_1 t + M_2 S_2 t \\ &= (M_1S_1 + M_2S_2)\, t \end{aligned}$$

(Where M_1 is the mass of water, S_1 is its specific heat, M_2 is the mass of calorimeter and S_2 is its specific heat and t is the rise in the temperature of water and calorimeter)

As such the calorific value of the fuel will be

$$\frac{1}{m}(M_1S_1 + M_2S_2)\, t$$

Example 1. If 5 kg of wood is required by a family to cook the food on a day, find out the amount of heat energy required by the family for that day in cooking their food. The calorific value of wood is 17 kilo joules/g.

Solution : The calorific value of wood is 17 kj/g *i.e.,* on burning 1 g of wood 17 kj heat energy is produced; therefore, on burning 5x1000 g of wood 17x5x1000 kj heat energy will be produced.

Hence, the heat energy required will be 85×10^3 kj

Example 2 : *Gobar* gas produced by a gobar gas plant contains 80% methane gas. A family requires 18000 kj heat energy per day. How much *gobar* gas will be required by the family in a month of 30 days ? The calorific value of methane is 54 kj/g.

Solution : The heat energy required by the family per day is 18000 kj.

Therefore, heat energy required by the family in 30 days will be 30 x 18000 kj.

54 kj heat energy is obtained from 1 g of methane. Hence 30 x 18000 kj heat energy will be obtained from $\frac{30x18000}{54}$ g of methane.

As gobar gas contains 80% methane, *i.e.,* 80 g methane is obtained from 100 g *gobar* gas. Therefore $\frac{30x18000}{54}$ g methane will be obtained from $\frac{100}{80} \times \frac{30x18000}{54}$ g *gobar* gas.

$$= 12500 \text{ g } gobar \text{ gas}$$

$$= 12.5 \text{ kg } gobar \text{ gas.}$$

Methane has high calorific value as compared to ethane because in methane each carbon atom is bonded with four hydrogen atoms (Methane CH_4), whereas in ethane each carbon atom is bonded with only three hydrogen atoms. Oxygen helps in burning but does not burn itself. Therefore, fuels containing oxygen atom do not have high calorific value, for example, wood, cowdung and alcohol, etc.

IGNITION TEMPERATURE OR KINDLING TEMPERATURE

The lowest temperature at which a substance catches fire or begins to burn is called *ignition*

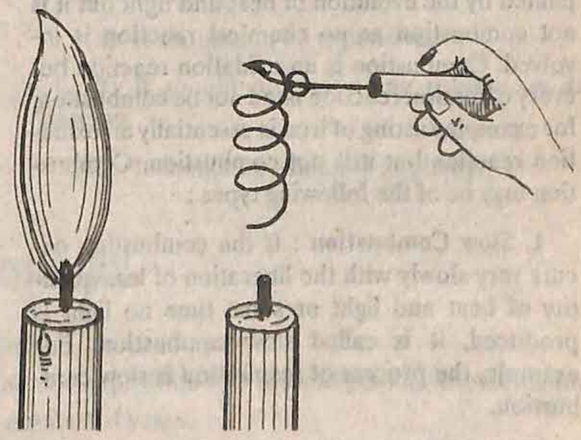

Fig. 2.6 A burning candle is extinguished as soon as its temperature falls below the ignition point.

temperature or kindling temperature. Every combustible substance has its own specific ignition temperature and without attaining this temperature it cannot be burnt.

If the ignition temperature of a substance is below the ordinary temperature, the substance will obviously take fire when brought into air, without the application of heat, *e.g.,* white phosphorus, sodium, etc.

We have learnt that without attaining its ignition temperature, a body cannot be burnt. This is the reason that water can even be boiled in paper cup without burning it. In this case the heat given to the paper by the flame is transferred to water without the former reaching its ignition temperature.

The flame of a burning candle is at once extinguished if a spiral thick copper wire is brought over its flame. This is because, copper spiral being a good conductor of heat conducts away the heat of combustion and the temperature falls below its ignition temperature, hence the flame is extinguished.

COMBUSTION

Combustion means burning. It takes place in the presence of oxygen. It is actually a chemical reaction accompanied by the evolution of heat and light. Glowing of an electric lamp is accompanied by the evolution of heat and light but it is not combustion as no chemical reaction is involved. Combustion is an oxidation reaction but every oxidation reaction need not be combustion, for example,rusting of iron is essentially an oxidation reaction but it is not combustion. Combustion may be of the following types :

1. Slow Combustion : If the combustion occurs very slowly with the liberation of less quantity of heat and light or some time no light is produced, it is called slow combustion. For example, the process of respiration is slow combustion.

2. Rapid Combustion : When the combustion is accompanied with the emission of intense heat and light, it is called rapid combustion. For example, the burning of magnesium ribbon, burning of LPG(liquefied petroleum gas), etc.

3. Spontaneous Combustion : If combustion occurs without bringing a spark or flame in contact with the substance, it is termed as spontaneous combustion. Such substances undergo slow oxidation accumulating heat until finally attaining the ignition temperature to burst into flame. Generally the fire caused in coal mines is an example of spontaneous combustion.

4. Spontaneous and Instantaneous Combustion : When white phosphorus, sodium, etc., are brought in air, they catch fire spontaneously and instaneously on account of the fact that their ignition temperature is below the ordinary temperature. Such types of combustion are known as spontaneous and instaneous combustion.

5. Explosion : Such types of combustion are accompanied by explosions besides the production of heat and light. Crackers and bombs, etc., are the examples of explosion.

COMBUSTIBLE AND NON-COMBUSTIBLE SUBSTANCES

Combustibles are those substances which can burn and catch fire easily like petrol, LPG, biogas, kerosene oil, wood, coke, etc.

On the other hand, non-combustibles are those substances which do not burn. For example, water and carbon dioxide. Water and carbon dioxide are used to put out fire and are known as fire extinguishers.

Conditions for combustion : We have noted that combustion takes place when combustible substance attains its ignition temperature in the presence of a supporter of combustion, *i.e.,* oxygen. This can be clear from the following examples :

(i) Combustion will not take place till the combustible substance is not present. Carbondioxide, water, stone, etc. cannot be burnt because these are not combustible substances.

(ii) A burning candle goes out if it is covered with a glass tumbler because the supporter of combustion, *i.e.*, oxygen is absent.

(iii) A heap of wood or biogas, etc., does not burn on its own though the combustible substance and supporter of combustion, *i.e.*, oxygen, both are present there. It is on account of the fact that they remain below the ignition temperature under these conditions.

Thus, the following are important conditions for combustion :

1. Presence of combustible substance.

2. Presence of the supporter of combustion, *i.e.*, oxygen.

3. Combustible substance should not be below its ignition temperature.

Incomplete combustion : Sometime the combustion does not take place completely on account of short supply of oxygen. Unburnt carbon and carbon monoxide is formed due to incomplete combustion of combustible substances. This leads to the pollution of atmosphere due to the entry of carbon monoxide and smoke in it and this also causes a wastage of fuel.

COMBUSTION OF FOOD IN LIVING ORGANISM

We take food in order to get energy from it. The releasing of energy from the food that we take is *slow combustion*. It takes place at the temperature of body in the presence of enzymes which work as catalyst.

The food taken by us is first broken down into smaller pieces during digestion which acts as fuel. This fuel is combined with oxygen to release the energy which is called *respiration*. This can be represented in a simplified form as follows :

Glucose (food) + Oxygen – > Carbon dioxide + Water vapour + Energy

Carbon dioxide and water vapour so formed during the combustion of food are expelled through various organs of living organism.

Ideal fuel : There are various factors which are to be considered for the selection of a fuel for domestic and industrial purposes. The following are some merits to be taken into account for its selection as an ideal fuel.

(1) It should burn easily and steadily.

(2) It should have high calorific value, *i.e.*, it should give much energy on its burning.

(3) Its ignition temperature should be proper, i.e., it shall not catch fire on its own at room temperature.

(4) Fuel should burn with a smokeless flame.

(5) It should not produce poisonous product on its burning.

(6) It should be easy and safe to store.

(7) It should be capable of being carried easily from one place to another.

(8) It should not be expensive.

(9) It should not leave any residue on its burning.

(10) It should be available in plenty.

SUMMARY

1. Fossil fuels are non-renewable sources of energy.
2. Coal is one form of fossil fuels formed from the decomposition of trees and plants, etc., inside the earth at high temperature and pressure for a number of years.
3. The products obtained during the process of destructive distillation are (i) coke (ii) coal gas (iii) coal tar and (iv) ammonium compounds.

4. Petroleum is another form of fossil fuel and is a complex mixture of hydrocarbons together with a small quantity of organic compounds containing oxygen, nitrogen and sulphur.
5. The gas commonly filled in gas cylinder is known as *Liquefied Petroleum Gas (LPG)*.
6. Various synthetic organic compounds derived from petroleum and natural gas are known as *petrochemicals*.
7. The fuel used in rocket is known as propellant and contains fuel as well as oxidiser.
8. Fuels can be classified as per the states of fuel into solid, liquid and gaseous fuels.
9. Fuels can also be classified into primary and secondary fuels. Primary fuels are used directly to produce heat, for example, wood, coal, and petroleum, etc. Secondary fuels are derived from primary fuels, for example, water gas, producer gas, coal gas, etc..
10. The amount of heat energy liberated on burning unit mass of fuel is called calorific value of fuel.
11. The lowest temperature at which a substance catches fire or begins to burn is called ignition temperature. Without attaining its ignition temperature a body cannot be burnt.
12. Combustion means burning which takes place when a combustible substance attains its ignition temperature in the presence of supporter of combustion, *i.e.*, oxygen.
13. The ideal fuel should burn easily and steadily, have high calorific value, should not catch fire at room temperature and should not leave residue on its burning. It should burn without smoke, be easy to carry and safe to store, should not be expensive and should be available in plenty.

QUESTIONS

Very Short Answer Type Questions

1. Write the full form of LPG.
2. Mention any two advantages of liquid and gaseous fuels over solid fuels.
3. Mention the gas present in coal gas other than methane and hydrogen.
4. Write two examples of fossil fuels.
5. What are two varieties of coal ?
6. Why a heap of wood does not burn on its own though the supporter of combustion, *i.e.*, oxygen is present there ?
7. Why sodium catches fire when brought in air ?
8. The calorific value of methane is 55 kilo joule/g. What does it mean ?
9. The flame of a burning candle extinguishes if a spiral thick copper wire is brought over its flame. Why ?
10. Give the reason for boiling water in a paper cup without burning it.
11. What is the main constituent of natural gas ?
12. What are petrochemicals ?

Short Answer Type Questions

1. Classify the following fuels according to their calorific values :
   Fuel : Coal, Dung cakes, Kerosene, Methane and Biogas.
   Calorific value : less than 20 kj/g, between 20 – 50 kj/g and more than 50 kj/g.
2. If you wish to purchase an ideal fuel, which characteristics of an ideal fuel will you keep in mind ?
3. In which form would you like to convert cow dung to get maximum advantage? Write three such advantages.
4. Write the laboratory procedure for the preparation of charcoal.
5. Hydrogen is not used as domestic fuel though its calorific value is very high. Give three reasons for this.
6. What are the conditions for combustion ?
7. What are propellants ? What are their advantages and where are they used ?
8. Why is petroleum called black gold ?
9. What is the composition of petroleum ?
10. What is the difference between primary and secondary fuels?
11. What is incomplete combustion ? How is it disadvantageous ?
12. How does the combustion of food take place in living organism ?

Essay Type Questions

1. Mention different types of combustion, giving an example of each type.
2. How will you justify that the reactions of photosynthesis and respiration are reciprocal to each other?
3. What is petroleum ? What different products are obtained from fractional distillation of petroleum. How can the yield of petrol/ gasoline in the fractional distillation of petroleum be increased ?
4. Draw the diagram for the destructive distillation of coal. What are the various products obtained from the destructive distillation of coal? Mention one use of each product.
5. How will you measure the calorific value of fuels ?

Chapter 3

NUCLEAR ENERGY

LEARNING OBJECTIVES

1. To understand the meaning of nuclear energy and to know that nuclear reactions are responsible for liberation of this energy.
2. To understand the isotopes of an element.
3. To understand about the nuclear fission and use of rarer isotope U^{235} in nuclear fission.
4. To know about the controllable and uncontrollable chain reaction and its application in nuclear reactor and atom bomb respectively.
5. To understand nuclear fusion and to know that the sun's energy is on account of nuclear fusion taking place therein.
6. To know about radiation hazards and nuclear waste and their damaging effect on living beings.
7. To know the causes of energy crisis and to overcome them.

INTRODUCTION

You have studied that the sun is one of the biggest sources of energy to this earth. Have you ever thought, what the reason is of this vast amount of energy in the sun and from where does this energy come in it ?

You might have heard of atom bomb and nuclear reactor which also release energy in great amount. In all the above cases, nuclear reaction takes place and energy released. The energy released during such reactions is called *Nuclear Energy.*

Now, the question arises as to what a nuclear reaction is and how is it responsible for releasing energy. Let us examine it. Actually, when two or more light nuclei combine together to form a heavier nucleus, the mass of the heavier nucleus formed is found to be slightly less than the sum of the masses of all light nuclei so combined. Similarly, when a heavy nucleus breaks up into the nuclei of new elements, there is a loss in mass. This loss in mass appears in the form of energy in accordance with Einstein's principle of equivalence of mass and energy represented by $E = mc^2$ where E is the amount of energy released, m is the loss in the mass before and after the nuclear reaction and also termed as *mass defect*, c is the velocity of light in vacuum equal to 3×10^8 m/sec. This forming of a new nucleus either by combining light nuclei or by disintegrating a heavy nucleus is called Nuclear Transmutation and the reaction that brought about the formation of new nucleus is called *Nuclear Reaction.*

According to Einstein's mass energy relation $E = mc^2$, 1 g of mass if totally converted into energy will produce 9×10^{13} joules of energy.

$$E = \left(\frac{1}{1000}\right) \times (3 \times 10^8)^2 = 9 \times 10^{13} \text{ joules}$$

$$\left[m = 1\text{ g} = \frac{1}{1000}\text{kg},\ c = 3 \times 10^8 \text{ m/sec}\right]$$

This is quite a large amount of energy that would be released by burning a few tonnes of coal.

As a matter of fact a nuclear reaction is quite different from a chemical reaction. In a chemical reaction there is a rearrangement of atoms to balance a chemical reaction, whereas in the case of nuclear reaction a new nucleus of the atom is produced which is not at all present in the reactants. The difference can further be illustrated with an example. When coal is burnt in oxygen, carbon dioxide is produced and heat and light are released. The chemical reaction involved in it is $C + O_2 -> CO_2$ + Light and Heat, which shows the rearrangement of carbon and oxygen atoms to form CO_2. In nuclear reaction, there is transformation of a nucleus of one element into the nucleus of another element.

The transformation of a nucleus of nitrogen into that of oxygen is represented by the following nuclear reaction:

$${}_{7}N^{14} + {}_{2}He^{4} - - > {}_{8}O^{17} + {}_{1}H^{1} + \text{Energy}$$

where

1. ${}_{7}N^{14}$ represents a nucleus of a nitrogen atom having a mass number 14 and an atomic number 7.

Mass Number represents the total number of protons and neutrons in its nucleus and *Atomic Number* represents the number of protons present in it. The number of electrons is equal to the number of protons. As such in the nucleus of ${}_{7}N^{14}$ there are 7 protons.

2. ${}_{2}He^{4}$ representing a nucleus of helium having a mass number 4 and an atomic number 2.

3. ${}_{8}O^{17}$ is representing a nucleus of an oxygen atom with a mass number 17 and an atomic number 8.

4. ${}_{1}H^{1}$ represents the nucleus of hydrogen atom.

Isotopes : If in atoms of an element the number of protons in its nucleus are always the same but the number of neutrons are different then such atoms are called the isotopes of that element. For example, in case of the atoms of

Fig. 3.1 Dr. Otto Hahn

uranium it is found that the number of protons in the nuclei is always 92, whereas the number of neutrons in the nuclei of all its atoms is not the same. Some uranium atoms have 143 neutrons and others 146 neutrons in their nucleus. The atom of uranium with 146 neutrons is represented as $_{92}U^{238}$ and the atom of uranium with 143 neutrons is represented as $_{92}U^{235}$. Thus atoms of the same element having the same atomic number but different atomic weights are said to be the isotopes of that element.

Nuclear fission : In the year 1939, a German scientist, Otto Hahn, with his co-worker Fritz Strassman, studied the effect of neutron bombardment on uranium atoms. To their great surprise they found that the uranium nucleus breaks up into two nearly equal parts with the release of a large amount of energy. *This process of breaking up of the nucleus of a heavy atom into two nearly equal parts with the release of a large amount of energy is known as Nuclear Fission.*

The fission of a heavy nucleus resulting from the impact of a neutron can be understood on the **basis of the following two kinds of forces operating inside the nucleus.**

1. Electrostatic force or the coulomb forces acting in the atomic nucleus which is attractive when the electric charges are opposite in nature and is repulsive when the electric charges are of the same nature. Inside the nucleus (where positively charged particles protons exist) it is *repulsive.* This repulsive force attempts to break up the nucleus into two halves.

2. Nuclear Force or Strong Force is always attractive and acts between protons, between neutrons or between neutron proton inside the nucleus of the atom and is effective only if these **particles are very close to each other and it decreases as the distance increases. It is on account of this nuclear force of attraction that the nucleus remains in its original spherical shape. In heavy nuclei, the distance between its particles would be greater causing this nuclear to force be smaller as a result of which the nucleus of heavy atom like uranium is unstable.**

The impact of a neutron on a heavy nucleus brings a resolution of a conflict between the opposite tendencies of Nuclear Force (attractive) and Electrostatic Force (repulsive) acting in the atomic nucleus. The small deformation caused by a neutron impact brings the Nuclear Force (attractive) to be correspondingly smaller and as such the Electrostatic Force (repulsive) gets the upper hand resulting in a break-up (fission) of heavy nucleus into two halves.

Natural uranium contains U^{238} and U^{235} in the relative amounts of 99.3 and 0.7 per cent

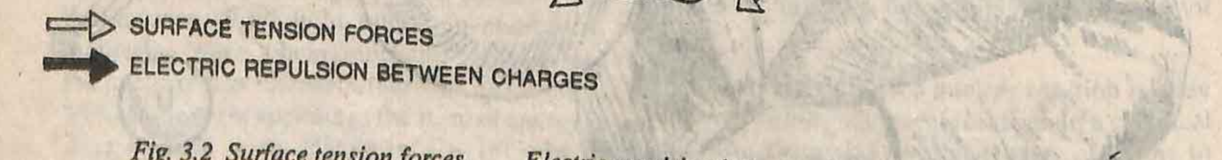

Fig. 3.2 Surface tension forces. Electric repulsion between charges. A massive nucleus breaks up in the fission process.

respectively. It is found that out of these two isotopes of uranium the rarer isotope U^{235} is much more fissionable than the more abundant U^{238}. It is found that U^{238} nuclei do not break up unless the bombarding neutron has high energy (fast moving neutron) whereas the U^{235} nuclei can be broken up by low energy neutron (slow moving neutron). In fact the breaking-up of U^{235} nuclei increases with decreasing velocity of bombarding neutron. Though the fast-moving neutron starts the fission of U^{238} nuclei but the neutrons thus produced in this fission are of less energy and cannot take part further in breaking up of anymore U^{238} nuclei and as such the reaction stops. In case of U^{235}, the fission can take place with slow-moving neutrons. In every fission of U^{235}, three more neutrons are also released. Generally out of these liberated neutrons one is absorbed or escapes and two neutrons further take part in the fission of other U^{235} nuclei. This process continues until all the U^{235} nuclei present in the system undergo fission.

Thus, if once the nuclear fission starts in a single U^{235} nucleus it continues at its own until all the U^{235} nuclei present therein break up. This type of nuclear fission is known as *chain reaction.* This type of nuclear chain reaction is shown in Fig. 3-3. In each fission of nuclei of U^{235} about 200 MeV (Millielectron Volt) energy is released

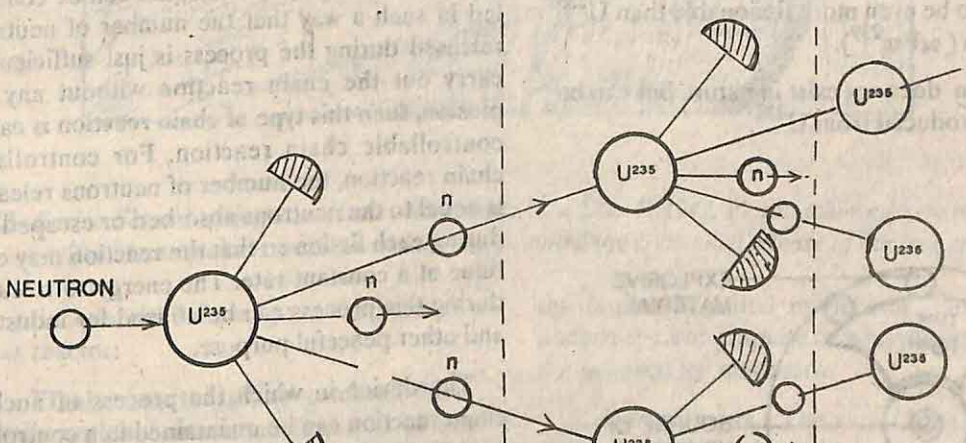

Fig. 3.3 Controllable chain reaction

(1 e.v. = 1.6×10^{-19} joule, 1 MeV = 10^{6}eV = 1.6×10^{-13} j)

The nuclear chain reaction can be classified in two types namely (1) Uncontrollable Chain Reaction and (2) Controllable Chain Reaction.

Uncontrollable chain reaction: We have noted that number of neutrons increases with each fission of U^{235} nucleus and as such more and more U^{235} nuclei break up within no time releasing the enormous amount of energy. As a result of this nuclear chain reaction there is nuclear explosion. This type of chain reaction is called uncontrollable chain reaction. The atom bomb is the result of this type of uncontrollable chain reaction. This type of chain reaction is possible only when the mass of U^{235} is more than a minimum fixed mass of it. This minimum fixed mass is known as the *Critical Mass*. Thus uncontrollable chain reaction is feasible only when the mass of U^{235} is more than its critical mass otherwise the neutrons released in this fission will escape out. The value of critical mass for uranium is about 10 kg. Another element which has turned out to be even more fissionable than U^{235} is plutonium (${}_{94}Pu^{239}$).

Plutonium does not exist in nature but can be artificially produced from U^{238}.

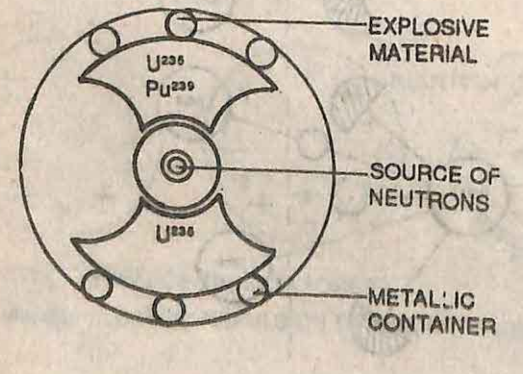

Fig. 3.4 :Atom bomb

Thus, in principle, in an atom bomb there are two separate pieces of U^{235} or Pu^{239}, each smaller than its critical mass and a source of neutrons placed inside a metallic container. These pieces are safe when they are apart from each other. When the bomb has to be exploded, these pieces are brought together automatically by a mechanical device and the bombardment of neutrons starts a chain reaction leading to a tremendous nuclear explosion in an incredibly small time. Such type of atom bomb was first used during the Second World War and was dropped at Hiroshima and Nagasaki in Japan. India carried out its first underground nuclear explosion on May 18, 1974 at Phokhran for peaceful purposes.

Controllable chain reaction and the nuclear reactor: The tremendous amount of energy releases out in a very short span during the uncontrollable chain reaction cannot be utilized for peaceful purposes and causes nothing but destruction.

In case the fission of uranium can be controlled in such a way that the number of neutrons released during the process is just sufficient to carry out the chain reaction without any explosion, then this type of chain reaction is called controllable chain reaction. For controllable chain reaction, the number of neutrons released is equal to the neutrons absorbed or escaped out during each fission so that the reaction may continue at a constant rate. The energy so released during this process can be utilized for industrial and other peaceful purpose.

The device in which the process of nuclear chain reaction can be maintained in a controlled way to produce energy at a particular rate is known as *Nuclear Reactor or Atomic Power Plant.*

Thus, in a nuclear reactor, each fission releases just enough neutrons to ensure that the number of uranium nuclei undergoing fission remains constant. This is a critical nuclear reaction. This type of critical nuclear reaction was first successfully carried out by the Italian-American physicist Enrico Fermi in United States on December 2, 1942.

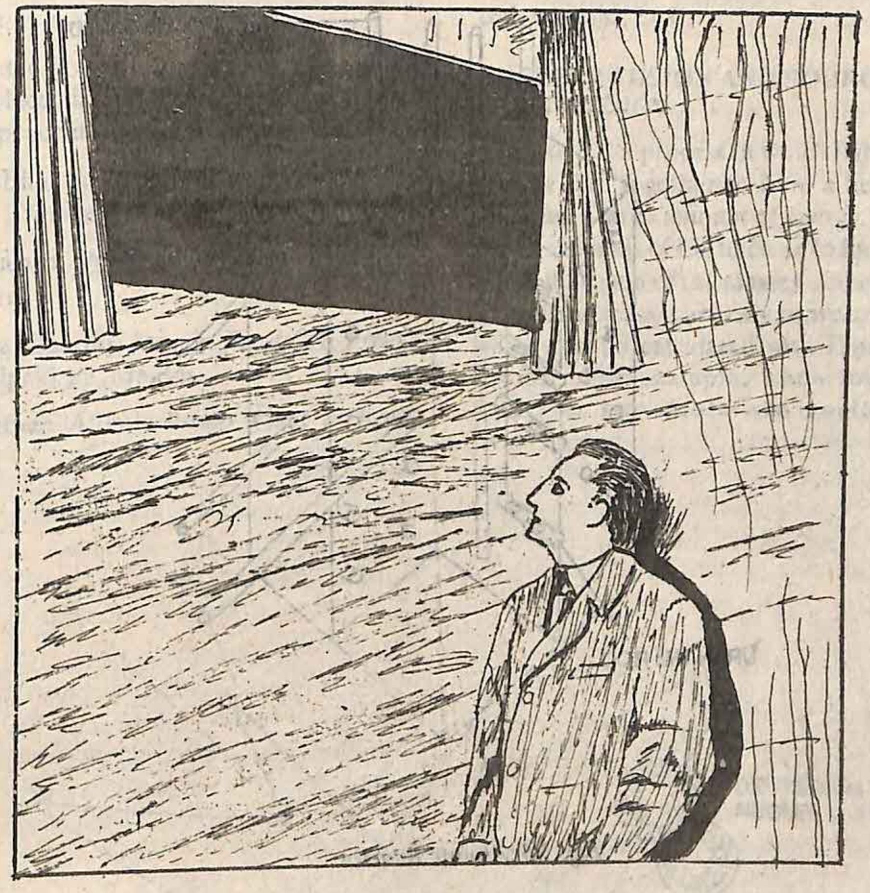

Fig. 3.5 Enrico Fermi looking at the wall which reads, 'On Dec. 2, 1942, Fermi achieved here the first self-sustaining chain reaction and thereby initiated the controlled release of nuclear energy.

In principle, the following are the parts of a nuclear reactor:

1. Fission material or nuclear fuel: Generally enriched uranium is used as nuclear fuel in the nuclear reactor. In enriched uranium the percentage of U^{235} is more than what it is in the natural uranium. This process of increasing the percentage of U^{235} in the natural ore of uranium is called the Enrichment. In India this process is done at the Nuclear Fuel Complex at Hyderabad whereas uranium ore comes mainly from the Jaduguda mines in Bihar.

2. Moderator : The material used to slow down the fast-moving neutrons produced during the fission is called moderator. Generally, in nuclear reactor graphite or heavywater is used as the material for moderator.

3. **Control rods** : The rate of fission can be controlled by absorbing the neutrons. In nuclear reactors the material used for absorbing the neutrons is either cadmium rods or boron rods. These rods can be moved in or outside the reactor, for controlling the chain reaction. If rods are moved more inside the reactor, more neutrons will be absorbed.

4 **Coolant** : The material used to carry out the energy produced inside the reactor during fission is called coolant. Generally, water, heavywater,

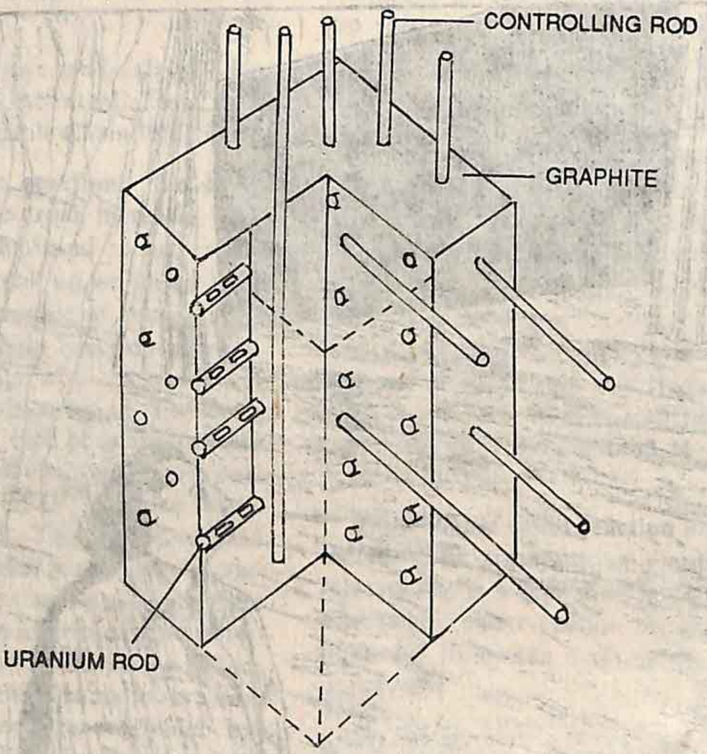

Fig. 3.6 :Atomic Reactor

air or liquid metals are used as coolant. Fig. 3.7 shows the atomic power plant using water as coolant. Here water carrying heat energy is used to run the turbines which run the generator to produce electricity.

5. **Protective Shield** : The radioactive radiation produced during the fission has to absorbed so that its harmful effects can be avoided. For this purpose, the atomic power plant is enclosed

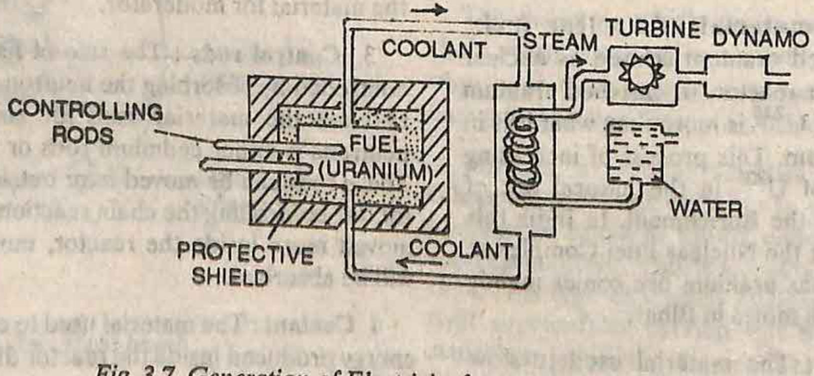

Fig. 3.7 Generation of Electricity from Atomic Reactor

by a thick concrete and metallic structure which is called *Protective Shield.*

The atomic power plants are working at the following places in India for harnessing atomic energy for peaceful and research purposes.

1. Bhabha Atomic Research Centre (B A R C), Trombay.
2. Tarapur Atomic Power Plant in Maharashtra.
3. Indira Gandhi Atomic Research Power Plant in Kalpakkam, Madras.
4. Rajasthan Atomic Power Plant in Kota, Rajasthan.
5. Narora Atomic Power Plant in Bulandshahr, U. P.

NUCLEAR FUSION AND SOURCE OF SUN'S ENERGY

Fusion is a process in which light nuclei combine or fuse together to form a heavier nucleus releasing a large amount of energy. As a result of fusion the mass of the nucleus so formed is slightly less than sum of the masses of the constituents. This loss in mass is actually converted into energy which can be calculated with Einstein relation $E = mc^2$. For example, when four hydrogen nuclei or two deuterium nuclei are fused

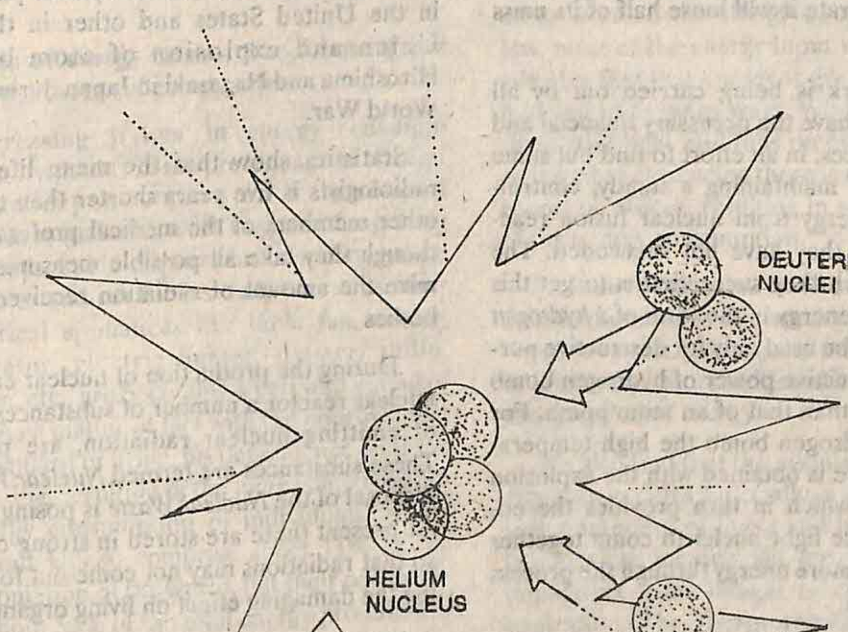

Fig. 3.8 Fusion of four hydrogen nuclei to produce helium nucleus.

together to form the nucleus of helium and about 26 MeV energy is released.

Actually, nuclear fusion is the main source of energy in Sun and stars. Though this reaction (nuclear fusion) appears to be simple but it is not one that can be caused to occur easily on the earth.

In the centre of the Sun there is multi-million degree temperature (10^7K) and a very high pressure, which provide environment for the fusion of hydrogen nuclei to form the nucleus of helium. In such fusion reactions the mass of the Sun is converted into energy from which we get the energy in the form of light and heat. The energy radiated out from the Sun is at the rate of 3.8×10^{26} joules per sec. If the Sun will continue to radiate out its energy with this rate it will loose half of its mass in 8×10^{12} years.

Intensive work is being carried out by all countries which have the necessary financial and scientific resources, in an effort to find out some practical way of maintaining a steady, controllable flow of energy from nuclear fusion reactions but so far they have not succeeded. The only way in which they succeeded is to get this large amount of energy in the form of a *hydrogen bomb* which can be used only for destructive purposes. The destructive power of hydrogen bomb is much greater than that of an atom bomb. For explosion of hydrogen bomb the high temperature and pressure is obtained with the explosion of atom bomb which in turn provides the environment for the light nuclei to come together and release still more energy through the process of nuclear fusion.

Radiation hazards : In the course of nuclear reaction radioactive radiations in the form of alpha, beta and gamma rays are emitted. These radioactive radiations consist of positively and negatively charged particles and electro-magnetic waves of very short wave-length. Radioactive radiations can penetrate our bodies and have destructive effects on living cells, cause cancer and damage genes and chromosomes.

The radiation damage can be of the following two types:

1. **Pathological damage:** In case the organism is exposed to radiation, which, being sufficiently severe, can lead to the death of that organism.

2. **Genetical damage** : These radiations can effect the reproductive organs which in turn harm the successive generations.

Pathological damage to individuals requires comparatively large radiation doses and, with the exception of atomic warfare, can be expected only in the case of serious accidents in atomic power plants. The world has already witnessed two major accidents in atomic power plants. One in the United States and other in the Soviet Union and explosion of atom bomb on Hiroshima and Nagasaki in Japan during Second World War.

Statistics show that the mean life span of radiologists is five years shorter than that of all other members of the medical profession, even though they take all possible measures to minimize the amount of radiation received by their bodies

.During the production of nuclear energy in a nuclear reactor a number of substances, capable of emitting nuclear radiation, are produced. These substances are termed *Nuclear Waste*.The disposal of the *Nuclear Waste* is posing problem. At present these are stored in strong containers so that radiations may not come out for producing the damaging effect on living organism.

Precautions are taken in designing the nuclear reactors so that these radiations coming out during the process of nuclear fission do not effect the workers working on the nuclear reactor and pollute the atmosphere. For this purpose, we have already seen that the nuclear reactor is surrounded by a thick concrete and metallic wall. Workers are provided with especial uniform through which these radiations cannot penetrate.

Radioactive substances are generally kept inside the lead containers as lead is a good absorber for such radiation.

ENERGY CRISIS

Energy is required for doing any type of work. Our demand for energy is increasing day by day with the increase of our different types of activities. From cooking our food to the running of transports and industries, energy is required in some form or other. With the increase of population and with the modernization and industrialization there is still a greater demand for energy. The world's petroleum and coal supplies (non- renewable sources of energy) are rapidly being exhausted in due course of time, posing the problem of *energy crisis* before us.

Causes of energy crisis : The following are some of the causes of energy crisis:

1. **Increasing trends in energy consumption by individuals** : In the present age of civilization man depends more on a number of appliances to make his work easy and for getting more comforts. He requires his own conveyance like scooter and car for his daily use. A number of electrical appliances like table fan, cooler, refrigerator, electric heater, toaster, radio, television, etc., are becoming a part and parcel of his life. As a matter of fact with the improvement in the standard of living, his dependence on these is increasing, resulting in the increasing trends in the energy consumption of individuals. Soviet Union and U.S.A. comprise about 11% of the total population of the world, but their consumption is about 50% of the total energy produced in the world.

2. **Increasing trends in the energy consumption in industry and agriculture** : All industries require power (electrical energy) for running them. More production from industries needs more energy. Tractors are generally used for ploughing the field which in turn consume energy. For agricultural production, pumping water from a tube-well or canal is required which again in turn needs electrical energy for running the motor. In short, the use of modern devices in agriculture increases trends in the energy consumption.

3. **Depletion in known stocks of fossil fuels :** Fossil fuels like coal, petroleum and natural gas are formed by the very slow decaying of plant and animal remains over a period of millions of years and are therefore called non-renewable sources of energy. If we continue to use these sources of energy at the present rate, which is much faster than the earth can recreate them, the world's coal and petroleum reserves will be exhausted very soon.

4. **Inefficiency and misuse of energy** : A good part of the energy is used up in overcoming friction between the different parts of a machine. In other words if the efficiency of machine is very low, most of the energy input will go to waste. We also find that energy is generally misused by many of us in many ways. We keep the switches of electric light and fans on even when it is not required or even when there is no one in the classrooms or offices, resulting in avoidable increase of the energy consumption.

5. **Industrialization and urbanization** : We find that new industries are coming up day by day because industrialization is the sign of progress of a country. More industrialization means more consumption of energy.

We also find that the population from villages migrates to cities especially in search of jobs, for better standard of living and in search of better facilities like medical aid, etc. This migration of population from villages to cities is called urbanization. The energy requirement of the individuals in cities is far more than in villages. Thus, industrialization and urbanization increase the energy consumption.

6. **Population growth** : Population growth is a very important factor for energy crisis. More population means more consumption of energy because each individual will require energy for his day-to-day work.

POSSIBLE SOLUTIONS FOR OVERCOMING ENERGY CRISIS

Various factors leading to energy crisis have just been discussed. Energy resources on the earth are limited and satisfying the energy requirements of an increasing population is posing a problem to us day by day. As such we have to find out possible solutions for overcoming energy crisis. The following are some of the suggestions:

1. **Population control** : Every one of us makes use of energy for getting our work done. We use petrol to run our scooter and car. We use fuel for cooking our food and use electrical energy in many electrical appliances. Increasing population will create more demand for consumption of energy. Therefore, a proper check on growth of population is required, especially in India, for meeting the energy crisis.

2. **Exploration of renewable sources of energy and emphasis on their use** : The energy sources are broadly classified under two categories :

(a) renewable sources of energy;

(b) non-renewable sources of energy.

(a) Renewable sources of energy are those which can be used up again and again, for example, the sun, wind, flowing water, ocean waves, animal waste and wood,etc. The sun is the enormous source of energy. Everyday it gives us light and heat. We have already seen some of the devices used to trap the sun's energy in the form of solar cells, solar cooker, etc. We have to find some more devices for trapping its energy. Let us hope solar power stations will be in operation in future to solve the problem of energy crisis. We have also to find out the actual mechanism by which plants and trees collect the sun's energy and transform it into useful products, to give it a real practical shape.

We have also studied how the wind's energy is trapped to run windmills which in turn generate electricity. The energy of flowing water is used to produce hydroelectric power. Animal wastes can be used in biogas plant to produce Biogas which is a good cooking gas. On the other hand the waste of a biogas plant can be used as manure in fields. The device for utilizing the ocean waves and tidal waves for generating electrical energy may come as a rescue for us from energy crisis in future.

As such, emphasis should be given for the use of solar cooker, solar cells, windmills, hydroelectric power plants and biogas plants as the energy sources. This may prove one of the possible solutions for overcoming energy crisis.

(b) The non-renewable sources of energy are those which have taken a very long time to form, for example, coal and petroleum. The danger of running out of these energy sources always exists. As such we should tap the renewable sources of energy, so that our dependence on non-renewable sources of energy becomes less.

3. **Reducing wastage of energy** : Efforts should be made for reducing wastage of energy. The switches of light and fans should be 'on' only when it is really needed. We should avoid the use of higher voltage bulbs where it is not required, leakage of oil, petrol and water, etc., from which energy can be obtained would be avoided. More efficient appliances consuming less energy should be used in place of inefficient, outdated appliances consuming more energy. We should also avoid heating water to higher temperature and then allow it to cool. The utensil used for cooking should be such that it consumes less energy; scooters and cars, etc., should be driven at a desirable speed for getting the maximum efficiency.

4. **Use of energy-efficient machines** : Machines should be designed in such a way that with the consumption of less amount of energy more work can be performed by them. Care should be taken that energy wastage should be minimum and the efficiency of the machines should be maximum. The boiler, if any, used in a device should be insulated properly so that losses of energy due to convection and radiation can be minimised.

5. **Judicious use of non-renewable source of energy** : Non-renewable source of energy, like

petroleum and coal are limited. As such these energy resources should be used judiciously so that their reserves may last long. As a matter of fact, we must reduce our dependence on petrol and coal by designing such machines and vehicles that do not use petrol, diesel or coal but use renewable sources for getting the requisite energy.

Nuclear reactors are also used as a vital source for producing electrical energy and can help in solving the energy crisis in the present day world but there always lies the problem of storing safely the harmful radioactive wastes and a fear remains of a dreadful accident that may occur at any time at a nuclear power station.

Question : 6.4 kj energy per minute is produced by a nuclear reactor. Find out the number of fissions taking place in it during an hour if the energy release per fission is 3.2×10^{-11} j.

Solution : In 1 minute 6.4x1000 joules energy is produced.

Therefore in 60 minutes 6.4x1000x60 joules energy will be produced.

Now 3.2×10^{-11} joules energy is released in 1 fission.

Therefore 1 joule energy will be released in $1/(3.2 \times 10^{-11})$ fissions and so, 6.4x1000x60 joules energy will be released in $\dfrac{6.4 \times 1000 \times 60}{3.2 \times 10^{-11}}$

$$= \left(\frac{6.4 \times 1000 \times 60}{3.2}\right) \times 10^{11} = 12 \times 10^{15} \text{ fissions.}$$

SUMMARY

1. During nuclear reaction mass-defect occurs. This mass-defect is converted into energy in accordance with Einstein's mass-energy relation $E = mc^2$.
2. Nuclear reactions are of two types :
   (a) Nuclear Fission
   (b) Nuclear Fusion.
3. Naturally-occurring uranium is found in two forms. ${}_{92}U^{235}$ and ${}_{92}U^{238}$. These are called isotopes of uranium.
4. If atoms of an element always have the same number of protons but different number of neutrons in the nucleus then these are called isotopes of that element.
5. Two types of forces act inside the nucleus of an atom: (1) Electrostatic force which is repulsive and (2) Nuclear force which is always attractive and is more effective, if the distance between the particles is less.
6. Splitting up the nucleus of uranium can be done by entering extra neutron.
7. Splitting up the heavy nucleus into almost two equal parts is called nuclear fission. It results in release of energy.
8. U^{235} is found suitable for nuclear fission as it can be split up by slow moving neutrons.
9. The process of multiplication of neutrons for inducing successive fission in other nuclei present in the system is known as chain reaction.
10. Uncontrollable chain reaction results in the form of explosion of atom bomb with the release of tremendous amount of energy.

11. Controllable chain reaction results in the form of Nuclear Reactor. The energy so released may be used for peaceful purposes such as producing electricity etc.
12. When two light nuclei fuse together to form heavy nucleus with the liberation of energy then this process is called Nuclear Fusion. The Sun's energy is on account of the Nuclear Fusion taking place in it.
13. Nuclear Fusion cannot be carried out in the laboratory because it requires very high temperature.
14. Hydrogen Bomb is a fusion bomb.
15. Nuclear Radiation can cause harmful effects such as cancer and damage genes.
16. Increasing trends in the energy consumption by individuals and for industry, agriculture purposes, inefficient and misuse of energy, depletion in known stocks of fossil fuels, industrialization and urbanization and population growth etc are some of the factors for Energy Crisis.
17. Possible solutions for overcoming the Energy Crisis are population growth control, exploration of renewable sources of energy, reducing wastage of energy, use of energy-efficient machine, judicious use of non-renewable sources of energy etc.

QUESTIONS

Very Short Answer Type Questions

1. Write the names of two forms of the element uranium.
2. State any one use of nuclear energy for mankind.
3. Write the names of two places in India where nuclear reactors are located.
4. Name the fuel which is generally used in nuclear reactor.
5. Find out the number of neutrons in a nucleus of ${}_{92}U^{235}$.
6. Name the nuclear reaction which is responsible for Sun's energy.
7. What type of nuclear reaction takes place in a nuclear reactor ?
8. Name the force with which two protons or two neutrons or a proton and a neutron attract one another.
9. Name the force which charged particles exert on each other.
10. What is the sum of protons and neutrons in the nucleus of ${}_{92}U^{238}$?
11. Mention two important uses of Nuclear Energy.
12. What is the function of cadmium or boron rods in nuclear reactor?

Short Answer Type Questions :

1. Differentiate between nuclear fusion and nuclear fission.
2. Differentiate between Controllable and Uncontrollable chain reaction.
3. Explain two possible ways by which we can overcome energy crisis.
4. What is Isotope ? Write isotopes of uranium.

5. Give two reasons for using $_{92}U^{235}$ for Nuclear Fission.
6. Mention any two harmful effects of Nuclear Radiation on our body.
7. Draw a labelled diagram of a nuclear chain reaction taking place in $_{92}U^{235}$ nuclei.
8. Explain why Nuclear Fusion cannot be used in laboratory to produce energy.
9. What is the main difference in the nuclear reaction that takes place in an Atom Bomb and in a Nuclear Reactor?
10. Suggest two points to stop wastage of energy.

Essay Type Questions

1. What is the main difference in the reaction that takes place in the Hydrogen Bomb and in an Atom Bomb ? With the help of systematic labelled diagram show the nuclear reaction taking place in an Atom Bomb. How this reaction differs from the reaction taking place in an Atomic Power Plant ?
2. Mention two factors responsible for energy crisis and suggest three measures for overcoming the same.
3. Describe the function of main parts of a nuclear reactor.
4. Why slow moving neutrons are preferred for Nuclear Fission as compared to fast-moving neutrons?
5. Fission of one $_{92}U^{235}$ nucleus releases $3.2x10^{-11}$ Joule of energy. Calculate the number of fissions required to produce energy at the rate of 10 mw for one day in a nuclear reactor.

Chapter 4

THE UNIVERSE

LEARNING OBJECTIVES

1. To know about GALAXY and the universe.
2. To know the unit in which the distances between stars are measured and to show that 1 light year = $9x10^{12}$ km (approx.)
3. To know about the Milky Way and constellations.
4. To understand that the Pole Star seems to stay still when all the other stars appear to move round the earth.
5. To understand the birth of a star.
6. To know about the different stages of a star's life.
7. To understand that the universe is expanding and to know about the Big Bang theory in this reference.
8. To know about the Solar System and its members .
9. To know about other objects in the Solar System such as satellites, asteroids, meteors, meteorites, comets.
10. To know the method for finding out the age of planets including the earth.
11. To understand that the earth has special place in the Solar System and is a unique planet.
12. To understand physical and biological components of the earth.
13. Understanding the importance of the presence of carbon dioxide in the atmosphere and to know about the greenhouse effect.
14. To know the history of space-exploration and the applications of space science.
15. To know about the evolution of life on the earth.
16. To know about the recycling of waste material.

INTRODUCTION

If we look at the sky during the day and at night we will observe objects such as sun, moon, stars etc. We know that the sun which is just a simple average-sized star is responsible for life on the earth. It is the nearest star to our earth and provides us heat and light. On its being much closer to us than any other star, it seems very much brighter. This is why we do not see stars during daytime. Though our sun is an average-sized star yet its size is fantastic, when compared with the size of the earth. There are stars, however, with diameters hundreds of times as great as the diameter of the sun.

Huge bunches or clusters of stars are held together by mutual gravitational attraction in space. Such a huge bunch or cluster of stars is

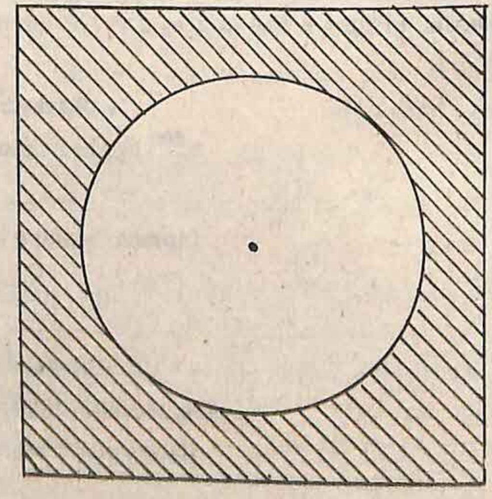

Fig. 4.1 Size of the sun when compared to the earth. The earth is the dot at the centre.

called a GALAXY. It is estimated by astronomers that there are some 100000 million (10^{11}) GALAXIES in the space. The existence of such GALAXIES forms what we call the *UNIVERSE*. It is also estimated that on an average each galaxy has about 100000 million (10^{11}) stars. As such, the total number of stars in the universe will be about $10^{11}x10^{11} = 10^{22}$.

The sun is about 150 million kilometres from the earth. The nearest star to the earth, after the sun, is Proxima Centauri. This is about 50000000 million kilometres away. As a comparison we can imagine the sun to be on the other side of the street, then on the same scale, Proxima Centauri would be 6500 kilometres away. As a matter of fact, this helps us to appreciate the vast emptiness of the universe. As the imagination travels through the space from star to star, there is nothing and nothing again for countless millions of kilometres. The distances between the stars are quite large and we use *light year* as the unit for measuring such distances. The *light year* is the distance travelled by light in one year. Light travels a distance of $3x10^5$ km in one sec. Therefore, the distance travelled by light in one year (365x24x60x60 secs) will be $3x10^5x365x24x60x60$ km $= 9x10^{12}$ km (approx.).

1 light year $= 9x10^{12}$ km (approx.).

The Milky Way : It is one of the galaxies of our universe. It comprises hundred thousand million stars. Close inspection on a smogless, cloudless night will show very many stars, some very bright, but most rather faint, in a bright band of white light that stretches right across the sky from north to south. It is called the *Milky Way* and is also known as *the Akash Ganga.* Actually this Milky Way is "*our Galaxy*" and the sun is one of the stars of this galaxy with which we are most familiar. Carefully assembled photographs establish the spiral shape of our galaxy. The two common shapes of galaxies in the universe are spiral and elliptical as shown in Figs. 4.2(a) and 4.2(b) respectively.

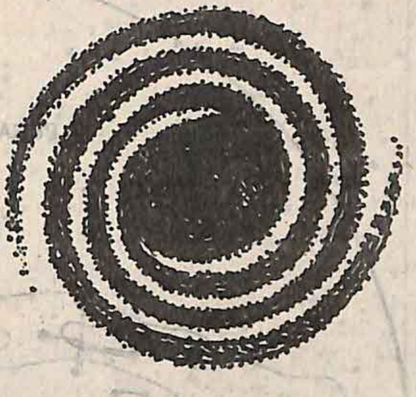

Fig. 4.2 (a) View of the Milky Way as seen from the front.

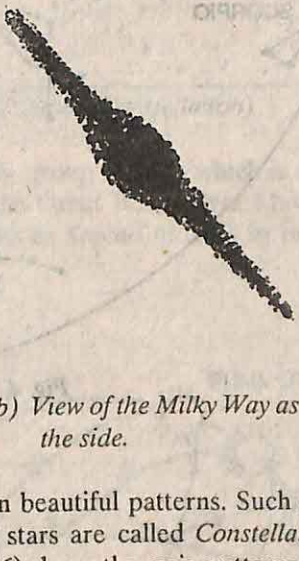

Fig. 4.2 (b) View of the Milky Way as seen from the side.

Constellations : On a clear night with no moon, about 3500 individual stars can be seen. Some of these stars appear to be arranged in groups or in beautiful patterns. Such groups or patterns of stars are called *Constellations.* Fig. 4.3 (see p. 46) shows the main patterns or groups of stars.

During early historical times, people imagined figures and scenes to exist in the patterns of the stars and named them accordingly. Fig 4.4(b) shows a picture of Orion, the Great Hunter, the way the stars have been used to outline him. It is visible during winter. Pleiades (*Kruttika*) is another group of stars which seems like a cluster of twinkling gems and is visible during winter.

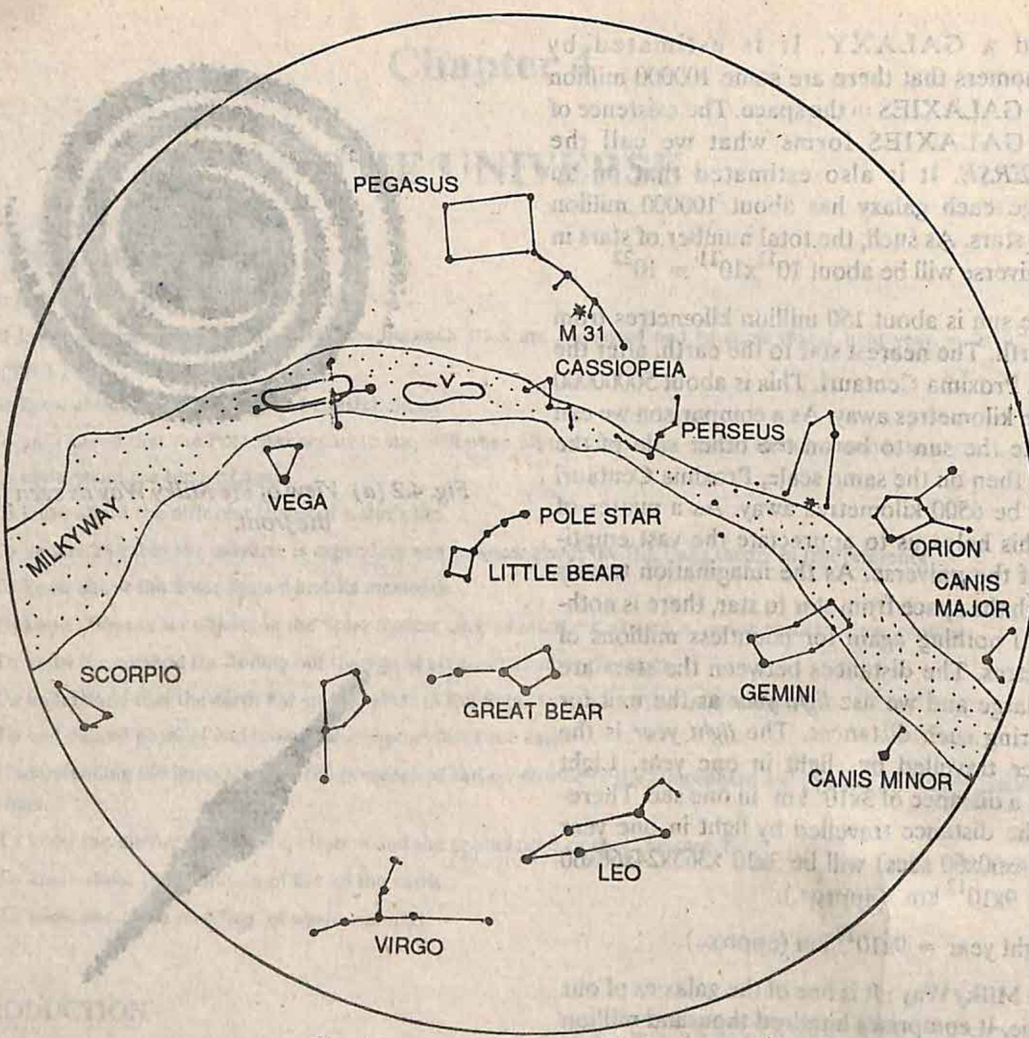

Fig. 4.3 Map of the night sky.

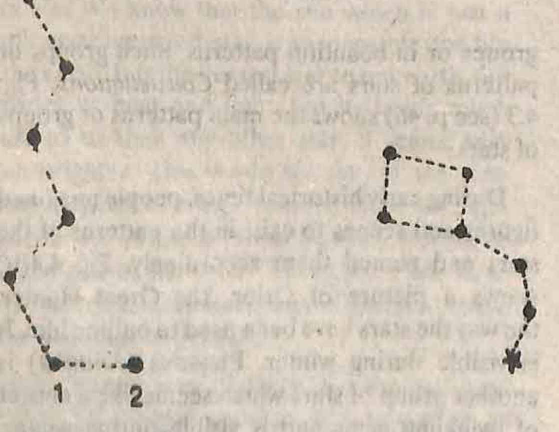

Fig. 4.4 (a): The constellations of Ursa Major and Ursa Minor..

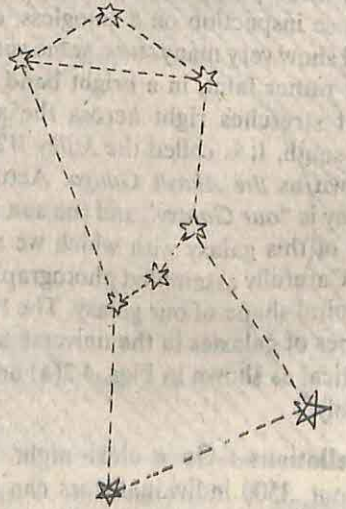

Fig. 4.4 (b) The constellation of Orion, the hunter.

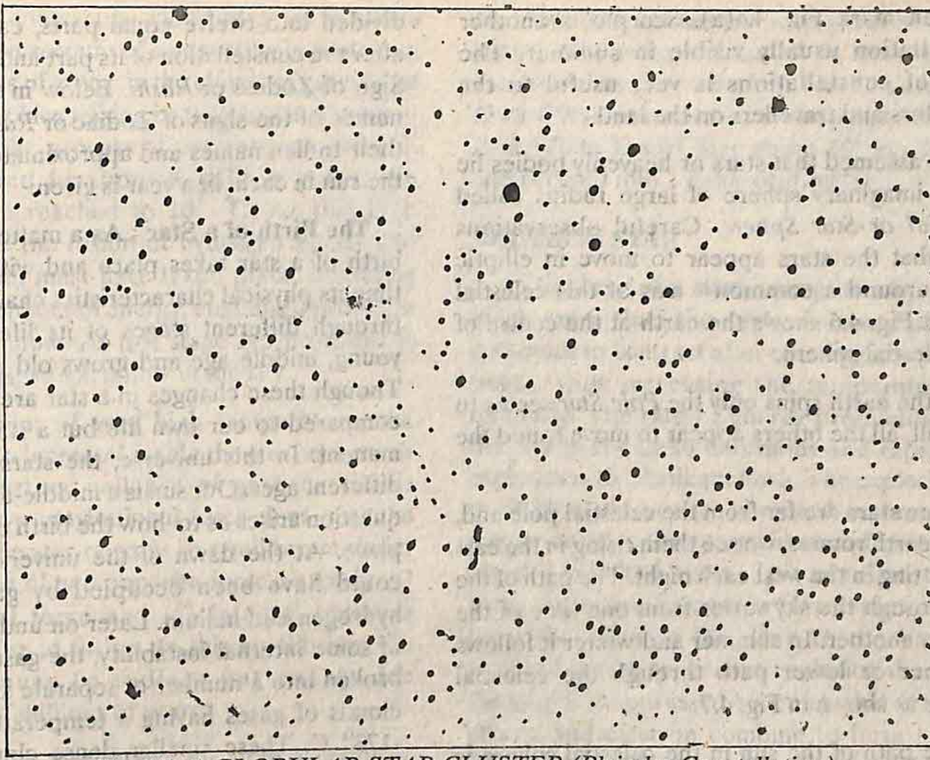

Fig. 4.5 A GLOBULAR STAR CLUSTER (Pleiades Constellation)

Such a cluster of twinkling stars is called a GLOBULAR STAR CLUSTER (Fig 4.5).

Another group of stars which is easily recognized is the Great Bear (Ursa Major) which is well known as *Saptarishi*. It is in the form of a

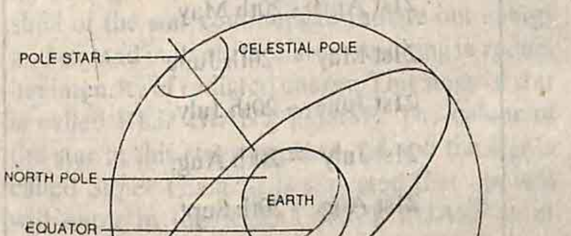

Fig. 4.6 Pole Star seems to stay still as the earth spins

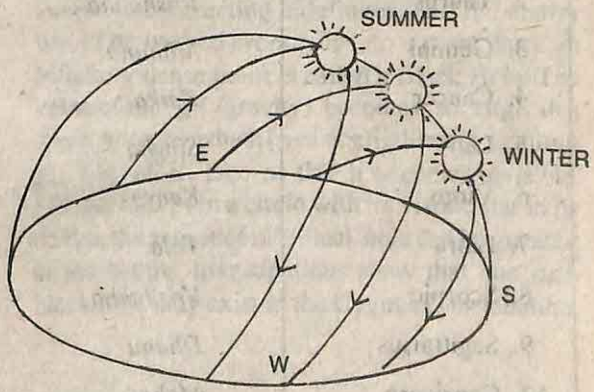

Fig. 4.7 The sun at noon

question mark Fig. 4.4(a). Scorpio is another constellation usually visible in summer. The study of constellations is very useful to the navigators and travellers on the land.

It is assumed that stars or heavenly bodies lie on an imaginary sphere of large radius called *Celestial or Star Sphere.* Careful observations show that the stars appear to move in elliptic orbits around a common axis of this celestial sphere. Fig. 4.6 shows the earth at the centre of this celestial sphere.

As the earth spins only the *Pole Star* seems to stay still, all the others appear to move round the earth.

Some stars are far from the celestial pole and, as the earth rotates, we see them rising in the east and setting in the west each night. The path of the sun through the sky varies from one time of the year to another. In summer and winter it follows a higher or lower path through the celestial sphere as shown in Fig. 4.7.

The path of the sun in the celestial sphere is known as the *Zodiac.* This path is imagined to be divided into twelve equal parts, each is named after the constellation of its part and is called the Sign of Zodiac or *Rashi*. Below in the chart the names of the signs of Zodiac or *Rashi* alongwith their Indian names and approximate duration of the sun in each in a year is given.

The Birth of a Star : As a matter of fact, the birth of a star takes place and with passage of time its physical characteristics change. It passes through different stages of its life, *i.e.*, attains young, middle age and grows old and dies out. Though these changes in a star are very slow as compared to our own life but a star is not permanent. In this universe, the stars are at their different ages. Our sun is a middle-aged star. The question arises as to how the birth of a star takes place. At the dawn of the universe, the space could have been occupied by gases, mainly hydrogen and helium. Later on under the action of some internal instability, the gases must have broken into a number of separate smaller dense clouds of gases having a temperature of about -173° C. These smaller dense clouds of gases would have then begun to contract and collapse under their own gravity.

Names of the Signs of Zodiac/*Rashis*	**Indian Name**	**Approximate duration of the Sun in the Signs of Zodiac/*Rashis***
1. Aries	*Mesha*	21st March - 20th April
2. Taurus	*Vrishabha*	21st April - 20th May
3. Gemini	*Mithuna*	21st May - 20th June
4. Cancer	*Karka*	21st June - 20th July
5. Leo	*Singha*	21st July - 20th Aug.
6. Virgo	*Kanya*	21st Aug. - 20th Sept.
7. Libra	*Tula*	21st Sept. - 20th Oct.
8. Scorpio	*Vrishakha*	21st Oct. - 20th Nov.
9. Sagittarius	*Dhanu*	21st Nov. - 20th Dec.
10. Capricorn	*Makar*	21st Dec. - 20th Jan.
11. Aquarius	*Kumbha*	21st Jan. - 20th Feb.
12. Pisces	*Meena*	21st Feb. - 20th March

This dense contracting cloud of gases is called *Protostar*. On account of contraction in protostar, the collisions of atoms in the clouds of gases must have taken place raising its temperature tremendously. As the process of contractions and collisions lasted for about a million years, the temperature reached to 10^7 °C. At this high temperature the fusion of hydrogen nuclei into helium nuclei must have taken place, liberating enormous amount of energy, enabling a protostar to begin to glow. At this stage the protostar is called star as we see it now in the sky.

On account of very high temperature, the pressure also increases inside the star, as a result of which further collapse of gaseous clouds under its own gravitational force does not take place and the star remains in equilibrium under the influence of two opposite forces, namely, *(i)* gravitational force and *(ii)* internal pressure produced due to fusion. In this equilibrium the star continues to radiate out energy for thousands of millions of years.

Final stages of a star's life : On account of fusion of hydrogen into helium in the interior of a a star, the quantity of hydrogen in the core of the star goes on decreasing gradually. A stage is reached when fusion would stop as the nuclear fuel 'hydrogen' will be exhausted. Under this condition the internal pressure of the star will drop and contraction of gaseous material under its own gravity will begin. However, the outer shell of the star continues to radiate out energy and expand in its surface area, resulting in reducing intensity of radiated energy. This stage of star is called RED GIANT PHASE. The colour of the star at this stage appears red and the star is called Super Giant. It is expected that our sun will enter in the RED GIANT PHASE after about 5000 million years from now.

WHITE DWARF STAR

A star with a mass equal to that of the sun would lose its outer shell after entering the red giant phase. The core part of the star, containing helium, gets condensed into an extremely dense ball, resulting in increase of its temperature so that the fusion of helium takes place into carbon nuclei. The energy liberated on account of this fusion makes the core glow. This is called White Dwarf Star. It continues so long as helium lasts. In a White Dwarf Star about 10^4 kg matter is compressed into 1 cubic centimetre.

NEUTRON STAR

In the case of a star, having its original mass much more than the sun's, the core of helium continues to contract after entering into red giant phase, thus increasing the temperature continuously. The rate of energy production inside the star becomes so enormous and rapid that it explodes with a brilliant flash. The explosion is so great that the energy liberated in one second may be equal to the energy liberated by the sun in about a hundred years. This is called a Super Nova explosion. Five supernova explosions have been recorded so far. Due to the back-kick received during supernova explosion the core of the star is compressed so much that individual proton and electron combine to form neutron. This type of stellar core is called a NEUTRON STAR. About a million tonnes of gaseous matter is compressed into 1 cubic centimetre.

BLACK HOLES

During supernova explosion, a star whose original mass is many times more than the sun's, the back-kick is extremely violent and the core keeps on contracting indefinitely and the matter would be packed eventually into a point. Such an infinitely dense point is called a Black Hole. The value of its "g" (gravity) becomes so large that even photons which have negligible mass cannot get out of it. Due to this it becomes invisible. If a star moves in a circle with no visible star in its centre, the presence of a black hole can be guessed at the centre. Investigations show that one such black hole may exist in the Cygnus Constellation.

THE EXPANDING UNIVERSE

This is our common experience that when a source of light or sound moves away from us or we move away from it, its frequency (number of vibrations per sec.) appears to have decreased and on the other hand if a source of light or sound moves towards us or we move towards it, its frequency appears to have increased. This is known as *Doppler Effect.*

The light emitted by a source of light gives its spectrum. In case a source of light moves away from us or we move away from the source of light, its frequency appears to have decreased and, as such, there will be a shifting towards the red side of its visible spectrum. This shift of spectral lines towards the red side of the spectrum is known as *RED SHIFT.* On the other hand, if the source of light moves towards us, its frequency appears to have increased and as such the shifting will take place towards the blue side of its visible spectrum.

On examining the spectrum of light emitted by various galaxies, it is found that *RED SHIFT* takes place in their spectra. As such, it can be concluded on the basis of Doppler's effect that all galaxies are moving away from us. Since we know that galaxies form universe, we can, therefore, conclude that the *universe is expanding.*

Origin of the Universe — Big Bang Theory : We have just studied that Red Shift clearly indicates that galaxies are not stationary but moving away from each other. An astronomer, Edwin Hubble, concluded that the speed with which these galaxies are moving away from each other is directly proportional to the distance between them. It means that the larger the distance between them the faster they are moving away from each other and, as such, the *universe is expanding.* As the universe is expanding, the number of galaxies per unit volume will go on reducing and more and more galaxies will be out of observable universe and a time may come when the universe will be just an empty space.

It is estimated that the origin of the universe has taken place at around 15×10^9 years ago. According to the Big Bang Theory, it is estimated that 15×10^9 years ago, the universe was one concentrated mass having a very high temperature of the order of 10^{10} °C. At that time the Big Bang, i.e., a big explosion took place and the fragments of this concentrated mass, thus, thrown off were known as galaxies and since then these galaxies are on their dramatic journey of moving away from each other, causing the universe to expand.

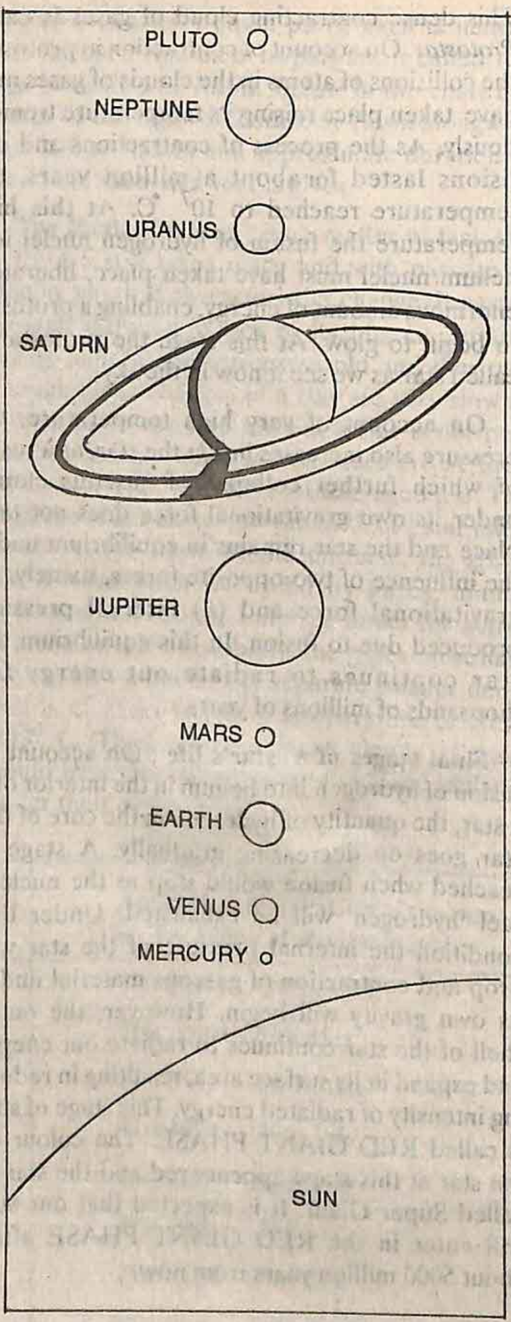

Fig. 4.8 The relative sizes of the planets compared with the Sun.

The Solar System

You have already studied that the sun is a medium-size star and was born in a similar way as other stars over 5000 million years ago. The sun provides us energy in the form of heat and light and is responsible for life on this earth. The earth is one of the nine planets which revolve round the sun in their elliptical orbits. The sun, the planets with their moons and other heavenly bodies such as asteroids, comets and meteors, which revolve round the sun, are together called the *Solar System*. Regarding the formation of the Solar System, one of the probable guesses is that about 5000 million years ago the sun was surrounded with left-over gases, which on condensing formed small objects. These small objects have collided and reassembled in the form of planets. These planets as per their respective distances from the sun are *Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto*.

The relative sizes and positions of planets compared with the sun is shown in Fig. 4-8 Though the diagram has not been drawn to a particular scale yet it gives a general idea of the sizes and positions of the planets and the sun.

Diagram below (Fig 4.9) also gives an idea of the planets revolving in their elliptical orbits around the sun as the present-day astronomers believe it to be.

The table system given on next page provides information regarding the planets in respect of their average distances from the sun, the time for one complete rotation about their own axis, time for completing one revolution around the sun, their diameters, mass as compared to the earth's, the number of their satellites and the atmosphere that they contain.

Mercury : Mercury is nearest to the sun. It is only possible to glimpse it near sunrise and sunset.

Venus : Venus is the second innermost planet of the Solar System. After the sun and moon it is

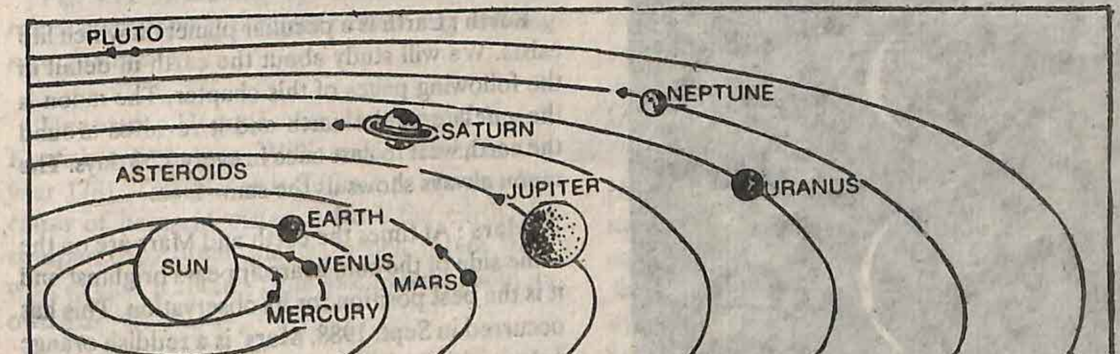

Fig. 4.9 The Solar System.

Table : The planets

Planet	Average distance from sun (kilometres)	Time for one rotation (earth units)	Length of year (earth units)	Diameter (kilo-metres)	Weight (com-pared to earth's)	Number of moons	Atmosphere
Mercury	57 000 000	60 days	88 days	4 800	0.05	none	carbon dioxide
Venus	107 000 000	250 days	225 days	12 000	0.8	none	carbon dioxide, nitrogen, water
Earth	150 000 000	24 hours	365 days	12 800	1.0	1	nitrogen, oxygen, water, carbon dioxide, argon
Mars	227 000 000	25 hours	687 days	6 400	0.1	2	carbon dioxide, nitrogen, water
Jupiter	780 000 000	10 hours	12 years	144 000	320	12	hydrogen, helium, methane, ammonia
Saturn	1 427 000 000	10 hours	30 years	120 000	95	9	same as Jupiter
Uranus	2 900 000 000	11 hours	84 years	48 000	15	5	same as Jupiter
Neptune	4 500 000 000	15 hours	165 years	45 000	17	2	same as Jupiter
Pluto	6 000 000 000	6 days	250 years	5 800	0.8	none	unknown

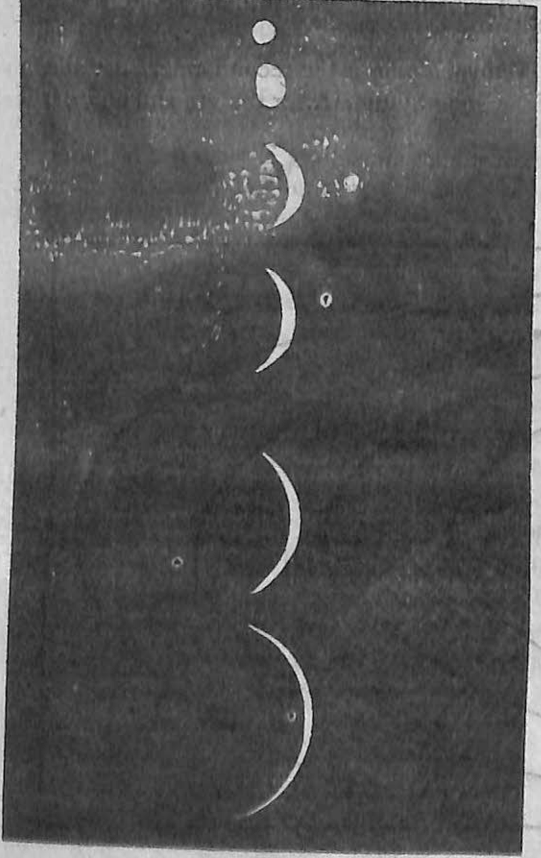

Fig. 4.10 The phases of Venus. Venus appears full when on far side of the sun. It appears as a thin crescent when almost between us and the sun.

the brightest object in the sky. It rises and sets near the sun each day. Venus is covered with clouds, hence it reflects most of the sunlight back into space. This is the reason for the dazzling apearance of Venus in the sky. The atmosphere on Venus is thirty times as dense as the earth's atmosphere. It also shows phases like the moon's as shown in Fig. 4-10.

Earth : Earth is a peculiar planet on which life exists. We will study about the earth in detail in the following pages of this chapter. The moon is the satellite of the earth and it revolves around the earth west to east once in every 27·3 days. The moon always shows us the same face.

Mars : At times the earth and Mars are on the same side of the sun, Mars appears brightest and it is the best position for its observation. This has occurred in Sept. 1988. Mars' is a reddish orange colour with dark lines on its face.

Jupiter : Jupiter is the giant of the Solar System. It has twice as much matter as all the eight other planets put together. This matter is mainly hydrogen and helium.

Saturn : Saturn is the second largest of the planets. It is surrounded by three flat rings that probably consist of dust and ice crystals. The beautiful picture of its ring system as obtained through space probe is shown in the Fig. 4-11 (see p. 53).

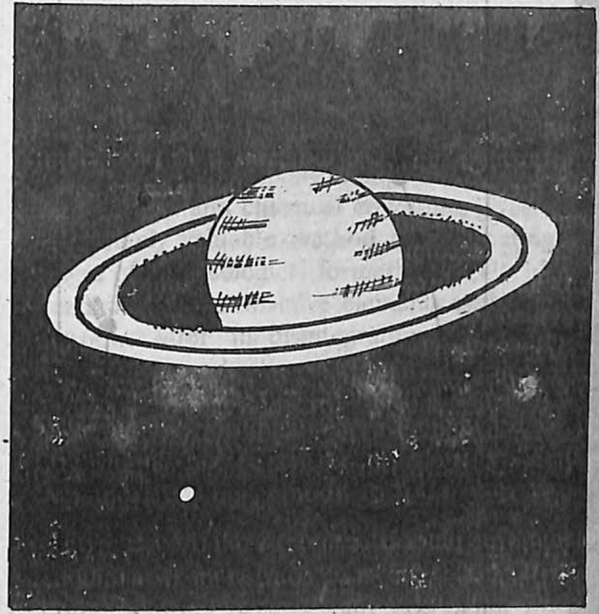

Fig. 4.11 A drawing of Saturn. These rings rotate at different speeds, the closest ring rotating most rapidly.

Uranus : Uranus was discovered by an English astronomer, William Herschel, in the year 1781. This planet is difficult to observe because of its great distance from the earth. As compared to other planets which rotate from west to east, it rotates from east to west about its own axis.

Neptune : Neptune was discovered by a French astronomer, U.J. Leverrier, in the year 1846. This planet is also difficult to observe because of its great distance from the earth.

Pluto : It is one of the smallest planets in the Solar System and was discovered only in the twentieth century, i.e., in the year 1930. It is so far out in the space that a very good telescope is needed to pick it up (Fig. 4-12).

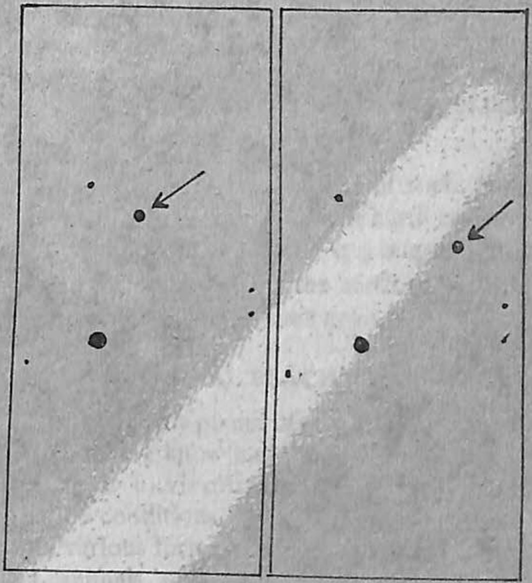

Fig. 4.12 Pluto, the latest planet to be discovered. This was in 1930. The two photos which were taken a day apart, show the planet moving against the background of the distant stars.

Other objects in the Solar System

Satellites : The body that moves around a planet is called a satellite. The earth has one satellite known as moon. These satellites are called Natural Satellites. Besides this, man has also sent satellites for various purposes, such as weather forecasting, television and radio transmission, etc. These satellites are called Artificial Satellites.

Asteroids : There are thousands of small objects between the orbits of Mars and Jupiter called asteroids. It is thought that the asteroids are the remains of a tenth planet, now broken up. They range in size from small rocks to large lumps of rocks. Some of the larger asteroids have been named, for example, Ceres, Pallas and Vesta. Asteroids are not visible to the naked eye.

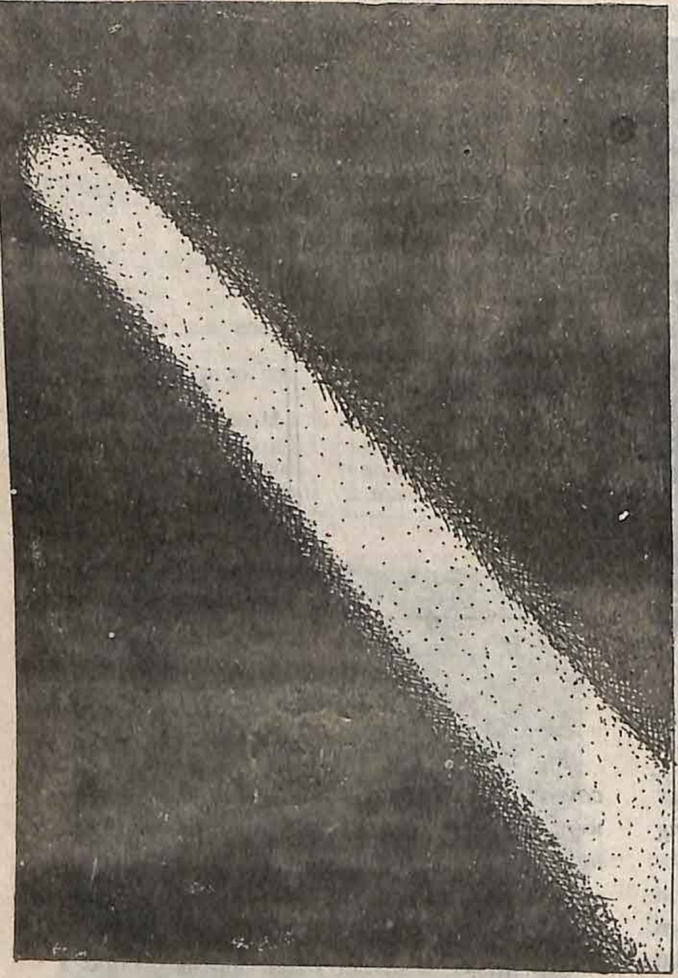

Fig.. 4.13 (a) A comet seen in the northern hemisphere in November 1948.

Meteors : These are called "falling stars" or "shooting stars". They are small fragments of matter attracted to the earth as it journeys through space. They are invisible in space, but on coming into the earth's atmosphere become white hot owing to friction with air, and flash across the sky as streams of light. They vaporise before they reach the earth's surface.

Meteorites : These are much larger objects than the meteors and may not vaporise before reaching the earth's surface and survive.

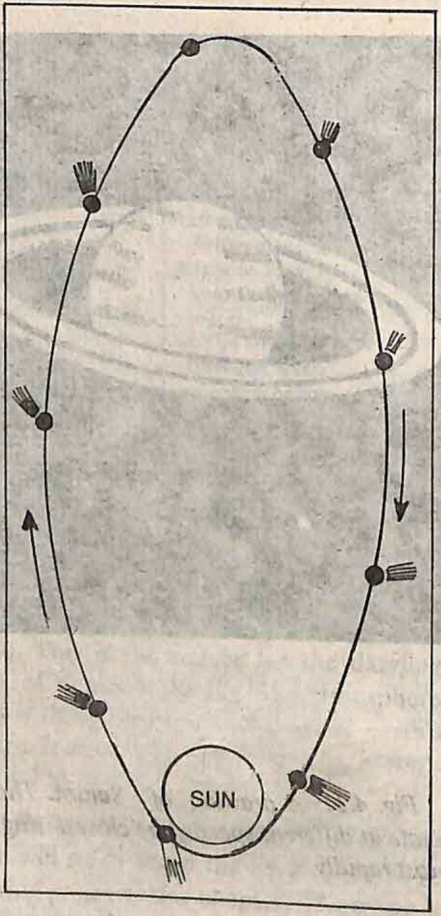

Fig. 4-13 (b) : Motion of Halley's comet.

Comets : Comets are objects that travel around the sun in very elongated orbits. Comets are made up of dust and gas. In shape they have a head and tail. They become luminous as they approach the sun, and the tail always points away from the sun as shown in figures 4.13(a) and 4.13(b) regarding the motion of the best-known comet 'Halley's Comet'. Halley's Comet appeared in 1682, 1759, 1835, 1910 and 1986. It shows that it has a period of about 76 years. Can you imagine when it will appear again? A comet is almost invisible until it approaches the sun and becomes heated.

Age of planets including the earth

The earth is one of the nine planets of the Solar System. It is said that the entire Solar System was born all at once. So, if the age of the earth can be found, the age of the other planets may be said to be almost the same. The decay of radioactive elements is in complete independence of physical and chemical condition, gives us an extremely valuable method for estimating the ages of old geological formations. ${}_{92}U^{238}$ is the father of all radioactive elements and the final product after its disintegration in the form of alpha, beta and gamma rays is a stable isotope of lead Pb^{206}.

The time period in which the initial number of radioactive atoms is reduced to one-half is known as "half-life" of the element. It means that at the end of two half-lives, only a quarter of the original amount will be left and at the end of three half-life periods, only one-eighth will be left, etc. The half-life of ${}_{92}U^{238}$ is 4.5 billion years. Age of the earth is found from the age of rocks found in the earth's crust. If the piece of the rock had a small amount of uranium embedded in it, as rocks often do, the latter would decay steadily and the lead resulting from the decay would be deposited at the same spot. The longer the time of the rock, the larger would be the relative amount of the deposited lead with respect to the left-over uranium. Thus, by measuring the ratio of U^{238} to Pb^{206} in various rocks, we can obtain very exact information concerning the time of the origin of the earth and other planets. This method is known as *Uranium Lead Dating* in which radioactive substance Uranium-238 is used as a clock.

Another method for measuring the age is known as *Carbon Dating* in which radioactive Carbon-14 (C^{14}) is used as a radioactive clock. The half-life of C^{14} is 5700 years. The atmosphere contains C^{14} atoms which are soon oxidized by atmospheric oxygen into molecules of atmospheric carbon dioxide. Since plants use atmospheric carbon dioxide for their growth, radioactive carbon (C^{14}) is incorporated into each plant's body, making all plants slightly radioactive throughout their lives. As soon as a tree or plant falls down no new supply of C^{14} is taken in, and the amount of radioactive carbon decreases as time goes on. As such by measuring the ratio of C^{14} to the ordinary C^{12} in such samples, we are able to estimate the dates of the origin of the plants.

By analysis of various samples of rocks and fossils from different regions of the earth and the moon, using radioactive clocks, it is inferred that the Solar System including the earth came into being about 4500 million years ago.

EARTH – A SPECIAL PLACE

Earth is the only planet of the Solar System on which life as we know has evolved. It is actually the earth's environment which provides favourable conditions for evolution and as such we find various forms of life on its surface, viz., plants, animals and human beings. Let us see what the favourable conditions are for the evolution of life on the earth. These are as follows :

(i) Presence of atmosphere.

(ii) Suitable temperature for sustaining life.

(iii) Presence of water on its surface.

(iv) Presence of protective blanket around it (like ozone layer) to prevent harmful ultraviolet radiation from entering the atmosphere.

One of the important things is that the Earth is just at the right distance from the sun. The earth lies between Venus and Mars. Venus is too hot to support any form of life and on account of its intense heat all the water evaporated and so excess of CO_2 in its atmosphere could not be dissolved, leading to further heating of this planet. Mars, on the other hand, being a smaller planet could not hold on to its carbon dioxide. In the absence of CO_2 in its atmosphere it could not retain the solar energy and, so, its temperature decreased and water there remains frozen.

The favourable distance of the earth from the sun and its appropriate mass enables it to retain water. Water absorbs excess of CO_2. The presence of water on the surface of the earth is responsible for the evolution of life and its survival. Through photosynthesis the plants further help in absorbing excess CO_2 and in turn increase the quantum of oxygen in the atmosphere which is essential for further evolution of higher forms of life. *On account of the evolution of life on its surface the earth has a special place in the solar system.*

Physical and biological components of the earth

Land, water, air are the physical components of the earth. It is on account of the presence of land, water and air that life exists on it.

Plants, animals, human beings and other organisms are the biological components of the earth. Both these categories of components interact and influence each other. Any change in the physical components brings about change in the biological components and vice versa.

The condition of land, water and air in a particular region depends upon the temperature, rainfall, seasons and climate of the region. On the earth there may be regions where the conditions both physical and biological suit a particular organism more than elsewhere. For example, camel can live in desert without water for days together. It means that living organisms make their bodies suitable for a particular physical component of the earth. With the change in the physical component of a particular region, the new generation of the organism may not adapt to it and in this process many species die out.

This is one of the reasons that many species of plants and animals have become extinct. On the other hand, organisms living in a particular region also bring changes in the physical components of the earth. Man, because of his superior intellect, has been able to create physical conditions to suit his needs, though this, in some cases, has brought problems for man himself. For example, the cutting of trees has created problem of soil erosion and floods.

Earth is hot inside — Changes since its origin: It is well known to mining engineers that as they dig deeper and deeper into the earth's crust they encounter a steady rise in temperature. Measurements made in these directions indicate that the rate of temperature-increase underground amounts to about 30^{0}C for each kilometre of depth. Since the temperature of rocks immediately under the earth's surface is about 20^{0}C, it follows that at a depth of only 2.5 km, the temperature of rocks may reach the boiling point of water. By extrapolating the observed temperature-increase to still greater depths, we find that, at a depth of about 50 km, the temperature of rocks reaches 1500^{0}C, which is their melting point. However, due to tremendoulsy high pressure (about 15,000 atmospheres) that exists at this depth, the rocks apparently do not really become fluid but acquire plasticity and flow like honey.

Initially, the earth was in red hot molten form, consisting mostly of the compounds of silicon, iron and magnesium with traces of other elements. During the process of condensation or the organisation of the earth the molten iron began to fall to the centre of the earth and the lighter constituents came to the surface to form the earth's crust. The iron that fell to the centre forms the core of the earth.

It was found that our earth has an onion-like structure, consisting of a large number of concentric shells or layers called *Differentiation*. The gases and water vapours trapped in were liberated to form the atmosphere and the ocean.

The three major layers (see Fig. 4.14 p. 57) of the earth are *(i) the Core, (ii) the Intermediate Mantle and (iii) the Outer Crust.*

(i) **Core** : The core consists of two regions namely the inner core and the outer core.

At the depth of about 2900 km from the earth's surface the larger of the outer core begins. The outer core contains mainly the molten iron with some nickel and sulphur.

The inner core begins at the depth of around 5000 km from the earth's surface. The temperature and the pressure at the centre would be very high. On account of very high pressure the iron remains in the solid form inspite of high temerature there. The details of earthquake waves passing through this core indicates it to be a rigid solid.

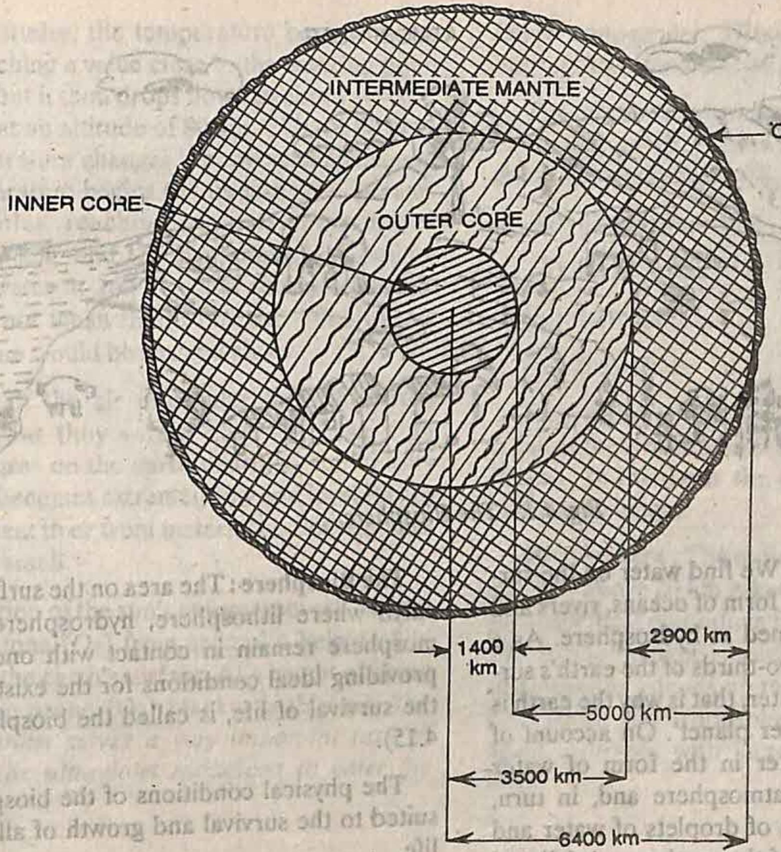

Fig. 4.14 The three major layers of the earth

Intermediate Mantle : The region between the outer core and the outer crust is known as the Intermediate Mantle. Starting after the outer crust it extends up to a depth of around 2900 km. It is said that this intermediate mantle mainly contains molten rocks.

Outer Crust : The thickness of the outer crust varies from place to place. It is thicker under continents and thinner under oceans and as such varies to a depth of about 10 km to 60 km from the earth's surface. The earth's outer crust has been under the process of constant reorganisation, forming new continents and oceans thereof.

We have studied that our earth has an onion-like structure consisting of a large numb[illegible] of concentric shells/layers which are interacting with one another. The outer layer consists of the following four divisions, viz., (i) the lithosphere, (ii) the hydrosphere, (iii) the biosphere and (iv) the atmosphere.

The Lithosphere : The outer crust of the earth is called the lithosphere. The thickness of the lithosphere varies from place to place. It is thicker under continents and thinner under oceans. Lithosphere has also been in a process of reorganisation on account of violent destructive phenomena like earthquakes and volcanic eruptions. It is a large reservoir of various minerals and deposits of coal, oil and gas which have played a vital role in the development of civilization.

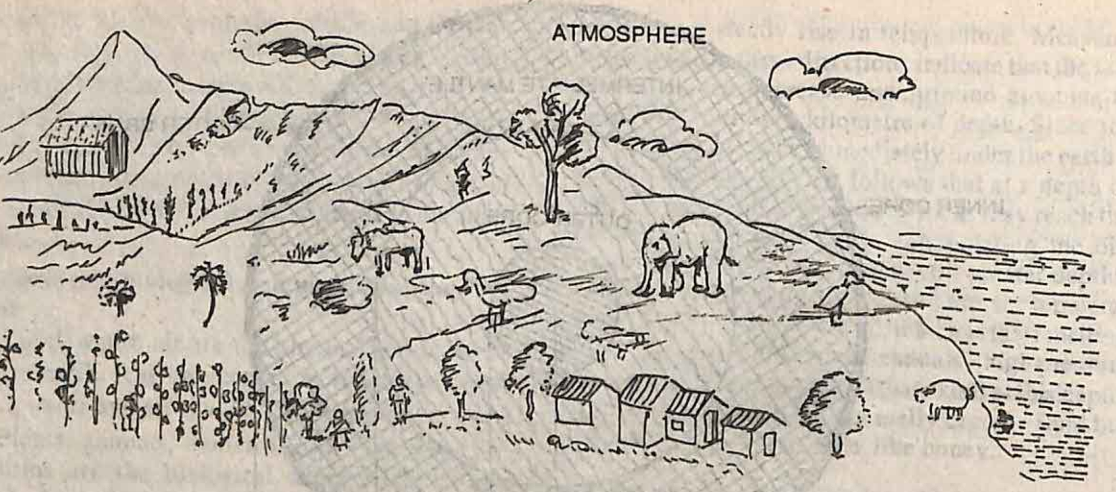

Fig. 4.15 The Biosphere.

The Hydrosphere : We find water on the surface of the earth in the form of oceans, rivers and lakes, etc. This is termed as hydrosphere. As a matter of fact about two-thirds of the earth's surface is covered with water, that is why the earth is sometimes called 'water planet'. On account of the sun's energy, water in the form of water-vapour mixes in the atmosphere and, in turn, condenses in the form of droplets of water and comes to the surface of the earth as rainfall and flows ultimately to the ocean. So, due to the sun's energy the circulation of water from hydrosphere to atmosphere, atmosphere to lithosphere and from lithosphere to hydrosphere remains in process.

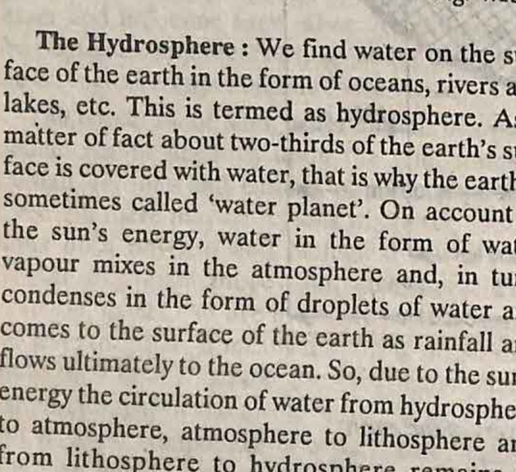

Fig. 4.16 The consitution of air in atmosphere

The Biosphere : The area on the surface of the earth where lithosphere, hydrosphere and atmosphere remain in contact with one another providing ideal conditions for the existence and the survival of life, is called the biosphere (Fig. 4.15).

The physical conditions of the biosphere are suited to the survival and growth of all forms of life.

The Atmosphere : Our earth is surrounded by air, like an envelope, which is called *Atmosphere*. Though this atmosphere extends upto a height of about 1600 km. from the earth's surface but 99% of the air of the atmosphere is confined only to a height of about 40 km.

The air is a mixture of different gases (see Fig. 4-16). The main gases are nitrogen 78% and oxygen 21%. Other gases present in it are argon carbon dioxide, hydrogen, etc. 1.0%. Apart from this, water vapours and dust particles are also present in it, which decrease as we go up. About above 12 km, air contains no water vapour at all.

As we rise above the earth's surface, the air becomes thinner and the temperature of the air decreases with increasing attitude at the rate of about 6°C/km. It has been found that the decrease in air temperature continues only upto an altitude of about 20 km, where it reaches a minimum of about -60° C (210° K). At still higher altitudes, the temperature begins to rise again reaching a value close to the freezing point of water, but it then drops down to about −90° C (183° K) at an altitude of 80 km. Above 80 km, the temperature changes are reversed again, and the temperature begins to increase with increasing altitudes, reaching room temperature at about 130 km and the temperature of boiling point of water at 160 km and so on. However, this does not mean that if one ascended to this altitude one would be roasted alive.

Although the air molecules there have the velocity that they would have at these high temperatures on the earth's surface, the density of the air becomes extremely low and its ability to conduct heat to or from material bodies becomes negligibly small.

The action of the sun's energy converts oxygen (O_2) to ozone (O_3) from around a height of 16 km from the earth's surface. At a height of about 23 km the ozone (O_3) blanket is thickest. *The ozone blanket serves a very important task of blocking the ultraviolet radiations to enter the lower atmosphere.* Ultraviolet radiations are harmful to us and can cause skin cancer.

The whole atmosphere may be considered as consisting of the following layers of air lying above each other (see Fig. 4-18 p.60):

(i) Troposphere

(ii) Stratosphere

(iii) Ionosphere

(iv) Exosphere

Troposphere : The lower layer of atmosphere is called the troposphere. It extends up to around 20 km. In this layer the temperature falls with increase in height.

Stratosphere : The moistureless and cloudless air layer above 20 km is known as stratosphere. It provides ideal conditions for flying of jet aircraft. The ozone blanket is thickest in this layer. The stratosphere extends up to a height of around 50 km above the troposphere. The temperature again increases with increase of height in this layer.

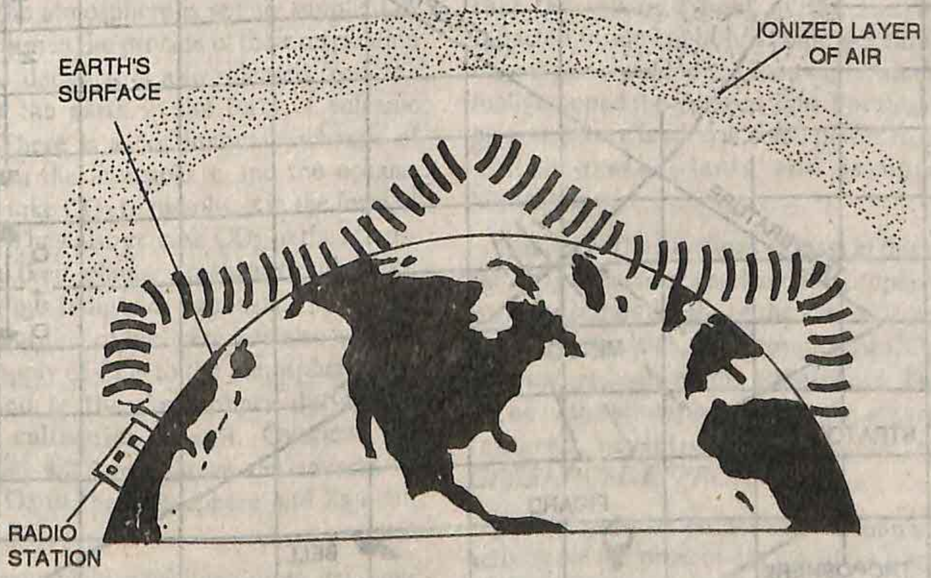

Fig.. 4.17 The ionosphere reflecting radiowaves back to the earth's surface

Ionosphere : This layer possesses a high degree of electrical conductivity because of the presence of free electrons and positive ions and is therefore a good reflector of radiowaves, thus, making the receiving of broadcasting programmes possible (see Fig. 4.17 p.59).

The ionosphere is subject to continuous bombardment by other high-energy radiations. These are deflected by the magnetic field of the earth to the poles, where they produce coloured light, streamers and glows, mainly red and green. This magnificent phenomenon is called the Aurora.

The importance of the presence of carbon dioxide in the atmosphere and the greenhouse effect

The presence of carbon dioxide in the atmosphere plays an important role, as it is required by

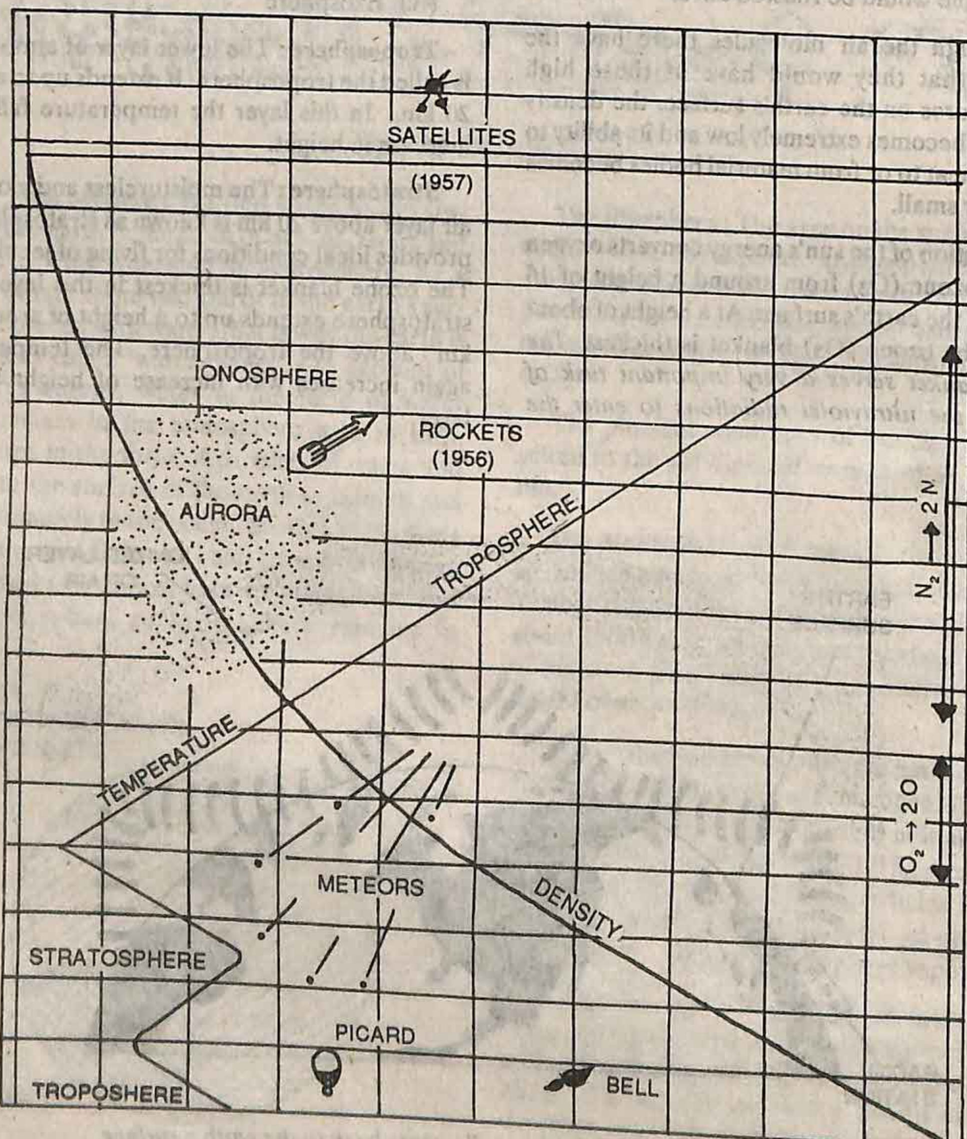

Fig. 4.18 Density and temperature of the earth's atmosphere at high altitudes.

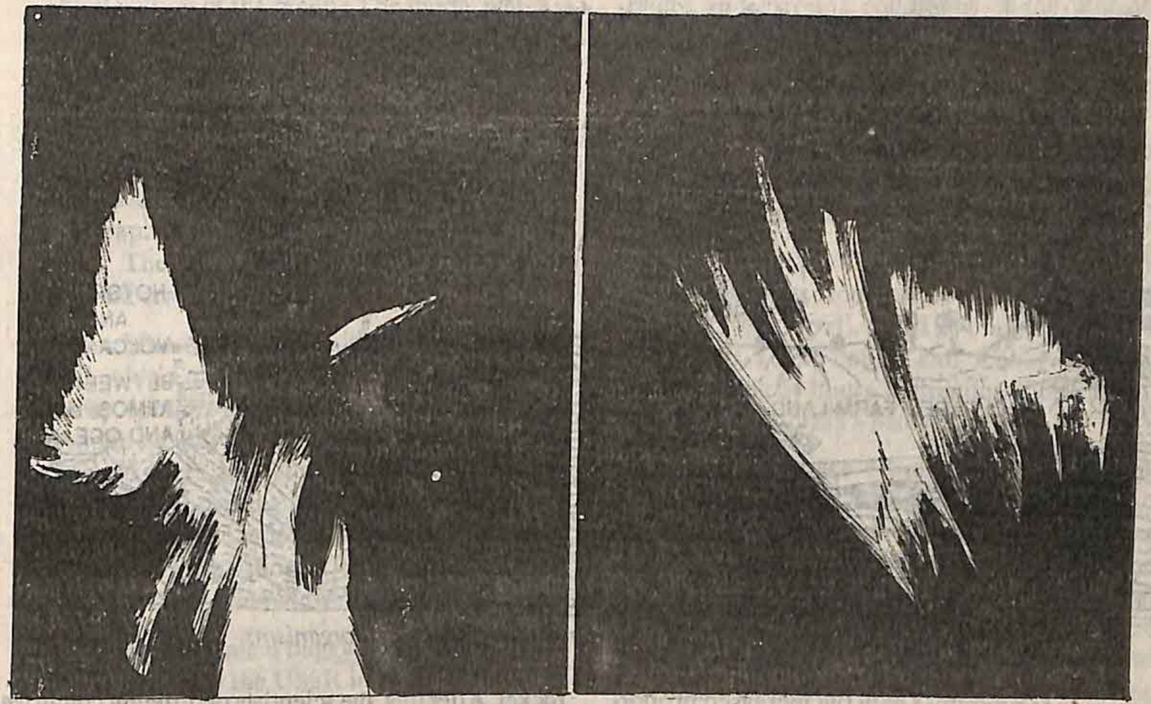

Fig. 4.19 Auroral Droperies.

green plants to prepare their food. Carbon dioxide in the atmosphere is mainly supplied by living organism in the process of their respiration and in their decay. It is also released from the interiors of the earth in the form of volcanic eruptions. There is a continuous exchange of CO_2 between the atmosphere and the oceans. The oceans take CO_2 to dissolve it in the form of carbonates. They also release CO_2 to the atmosphere from their plants, organisms and rocks, etc. The various industries established by human beings and burning of fuels, etc. are also a major source of supply of CO_2 to the atmosphere. It is also supplied to the atmosphere during the process of cultivation of soil. Overleaf in diagram (Fig. 4.20) are shown the sources of supply of CO_2 to the atmosphere and its main consumers.

Some of you while travelling during day time in car with covered glass windows might have noted that the interior of the car becomes heated up considerably. This is on account of the fact that the infrared light of the sun which is reflected inside could not come out through the closed glass windows. These glass windows actually trapped the infrared light. For this reason a glass structure is used at some places to cultivate potted green plants and is named as 'Greenhouse'.

Similar to the functions of glass in this respect, the CO_2 molecules also have the property to absorb the infrared light of the sun reflected from the earth. As such, the presence of CO_2 in the atmosphere heats up the atmosphere. This heating up of the atmosphere due to the absorption of infrared radiation by CO_2 is termed *GREENOUSE EFFECT.*

It is found that on account of man's various activities in the present-day world the percentage of CO_2 in the atmosphere is increasing fast, resulting in an increase of the average temperature of the earth. The consequence of this in-

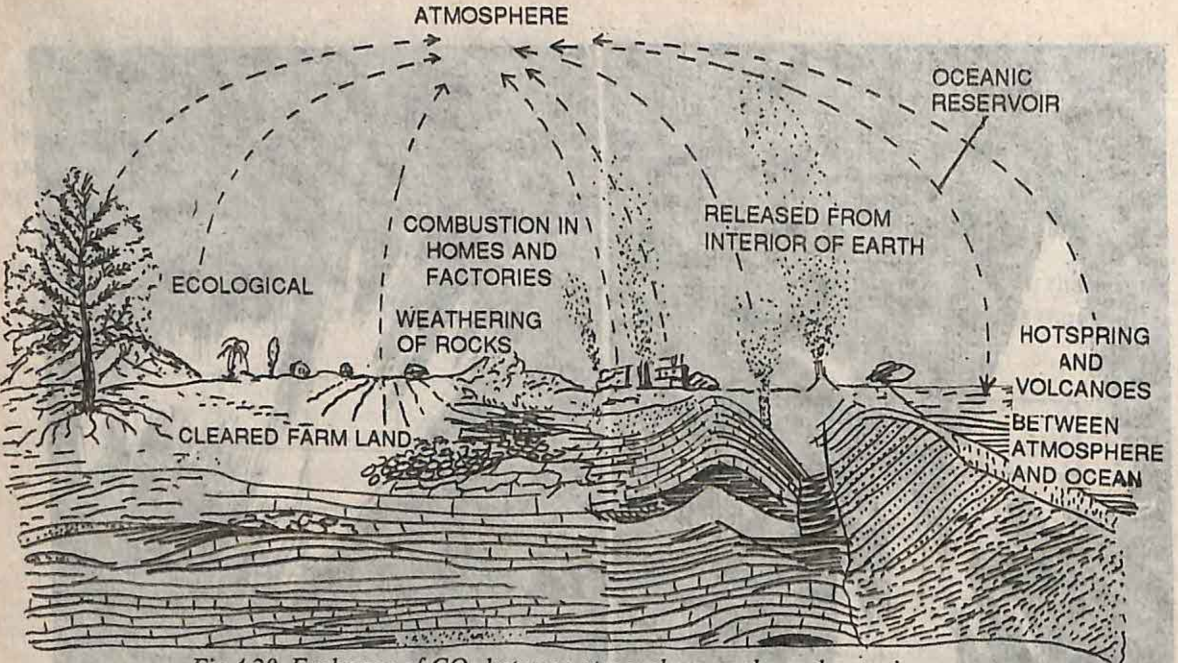

Fig.4.20 Exchange of CO_2 between atmosphere, rocks and organisms.

crease in temperature with the increased proportion of CO_2 in the atmosphere is yet to be analysed.

SPACE EXPLORATION

History of space exploration : In order to know more and more about other planets and objects of the Solar System and to get more information about the earth's atmosphere, an intensive exploration of the space has been undertaken by the scientists. Later on, the aims of space exploration have gone on continously multipling covering more and more fields of investigations.

The question arises how this space exploration has become possible? How the spacecraft has become a reality in the space? The space journey has become a reality on account of the use of the 'Rocket' which was first used by an American Scientist named Dr. Robert H. Godard in 1980 based on the principle of Newton's third law of motion which states that 'for every action there is an equal and opposite reaction'. In 1920, for the first time, a liquid fuel was used in a rocket. After this, the scientists of different countries have designed rockets as per their need. The rocket is the carrier of spaceship into space.

We have learnt that the moon is the natural satellite of the earth orbiting around it. Man-made satellites have also been launched into space from time to time. Actually, the space exploration started with the launching of the first man-made satellite by the *USSR on 4th October 1957.* An 18-month year was observed from 1-7-57 to 31-12-1958, when the USA and USSR announced launching of artificial satellites. This year came to be known as *Geophysical Year*. *Explorer I* was the first satellite of the USA, launched on Jan. 31, 1958. It has discovered a strip of electrically charged particles trapped in the earth's magnetic field and is known as *Van Allen Radiation Belts.*

Yuri Gagarin of the USSR was the first cosmonaut who went into space on April 12, 1961.

Valentina Tereshkova was the first space woman of the world who went into space in June 1963.

Exploration of the moon : The moon, which is a natural satellite of the earth was explored time and again by space probes. We have studied that one face of the moon is visible to us as its period of rotation about its own axis equals its period of revolution round the earth. The other side of the moon, which is not visible to us, was first photographed *in 1960 by the Russian space probe Luna-3.* The photograph shows that it contains rocks and craters.

First Man on Moon : Neil A. Armstrong and Edwin Aldrin of the USA were the first men who went by *Apollo-11* and set foot on the surface of the moon on July 21, 1969. Samples of lunar soil and rocks were brought back by them for examination. It shows that there is no water, vegetation and life on the moon. The atmosphere is also very rare. The variation of temperature is from about 110°C at midday to about 150°C at night.

The first unmanned buggy Lunakhod-I on the moon was sent by the USSR in Nov. 1970. Luna-16, the Soviet unmanned spaceship, brought moon rock on the earth. The analysis of rock samples shows the age of the moon as 4.5 billion years.

Exploration of the planets : After the exploration of the moon, the other planets of the Solar System, e.g., Mercury, Venus and Mars have also been explored by the USA and USSR space probes, in order to find out the possibility of existence of life, if any.

Mariner-9, a spaceship of the USA has taken the photographs of Mars, from a very close range which showed that it has craters with smooth boundaries. It has also shown the signs of volcanic eruption. The USA sent its first spacecraft (unmanned) Viking I to Mars which landed there on 20th July, 1976. The photographs sent by this spacecraft revealed that there is no life on Mars. On analysis of further information it is found that Mars has a thin atmosphere, which mainly consists CO_2. Photographs taken of Mercury by Mariner-10, a spaceship of the USA from quite a close range showed that it contains craters of all sizes. There is no possibility of the existence of any life on it on account of the absence of atmosphere and extreme conditions of the temperatures on it.

Skylab : An 88-tonne orbiting space station was launched by the USA in May 1973 in order to carry out various scientific experiments. In July 1975, there was a joint Apollo-Soyuz test flight launched from America and Russia.

Space Shuttle : 'Columbia' is the world's first space shuttle that took off from Cape Canaveral, Florida, on April 12, 1981 alongwith two astronauts John Young and Robert Crippen. After making 54 hours 20 minutes of test flight, it landed in California's Mojave desert.

India and Space : India is one of the few countries (like the USSR, USA, France, Britain, Japan, China, etc.) which have explored space for the satellite communication and weather monitoring. In 1961, the department of atomic energy of India was made responsible for peaceful space research. Indian National Committee on Space Research (INCOSPAR) was established in 1962. It was reorganised under Indian National Science Academy (INSA) in 1969 and ISRO was established. In 1972, the Department of Space was established and ISRO came under this department.

On April 19, 1975, *Aryabhatta* (358.5 kg), India's first space satellite, was launched from the Soviet Union cosmodrome, for the purpose of collecting data on agriculture and to assert Indian space capabilities. It was built by the ISRO. It orbited the earth at an altitude of 594 km in 96.7 minutes at a speed of 800 km /sec.

On June 7, 1979, *Bhaskara-1* (444 kg), India's second satellite, was launched successfully from the Soviet Union, to carry out remote-sensing experiments, to study the Indian topography and to make the earth's observation. It orbited the earth in near circular orbit in 95.2 minutes at an inclination of 50.7°. It was designed and built by the ISRO with Indian expertise and machinery. It contained sophisticated instruments for carrying out remote-sensing experiments over India.

The mission objectives of Aryabhatta and Bhaskara were satisfactorily realized.

On July 18, 1980, *Rohini-1* (35 kg), India's third satellite, was launched with the purpose of testing the ground control system. It was launched by SLV-3 (India's Satellite Launch Vehicle) from Sriharikota High Altitude Range (SHAR), 100 km north of Madras. It orbited at a latititude of about 900 km once in every 97 minutes. It began India's quest of self-sufficiency in space technology.

Apple Satellite is India's first experimental geo-stationary communication satellite. *Geo-stationary satellites* have the same period of rotation as that of the earth (i.e., 24 hours); so it appears stationary over a fixed point on the globe. It was a telecommunication satellite which was put in a circular orbit at a height of 35,680 km and was right over the equator and at this height its period of rotation is equal to the earth's period of rotation.

Indian National Satellite System (INSAT) : Indian National Satellite System, i.e., INSAT-1 programme, is a multipurpose satellite system programme for *domestic telecommunication and meteorology, with capability of nation-wide direct television broadcasting to the rural communities of India.* The department of space is responsible for the establishment, operation and maintenance of INSAT-1 Series. So far, INSAT-IA, INSAT-IB, INSAT- IC, INSAT - 1D have been launched. Out of these INSAT-1B is successfully serving the purpose for which it was launched, i.e., for TV programme, radio programme and weather forecasting. The life-span of INSAT-IB is up to 31st March 1991.

Indian National Satellite INSAT-1D has also come in operation replacing the dying INSAT - 1B. This multipurpose satellite was launched from Cape Canaveral on June 12, 1990. It is available for telecommunications, television, radionetworking and round - the -clock weather watching. Under normal condition, INSAT - 1D should have a life span of seven years.

Application of Space Science

We have seen that the application of space science is manifold. It can broadly be placed under three heads:

(i) Collection of information about other planets and outer space.

(ii) Satellite communication.

(iii) Weather monitoring.

(i) Collection of information about other planets and outer space : It has already been told in this chapter that the USSR and USA have sent various satellites from time to time into the outer space to find out the possibility of the existence of life on other planets and to get information, e.g., atmospheric condition, temperature variation, etc. of the planets and the outer space. The photographs taken and sent by the satellites helped a lot to know more about other planets and outer space. On the other hand, Man has actually landed on the moon and brought various samples of rock and soil from it which has provided a lot of informations to the scientists.

(ii) Satellite communication : We have seen that the ionosphere reflects the radio waves and helps us to get the radio transmission at the other stations but on account of variation in the condition of ionosphere from time to time the transmission is either distorted or lost sometime. Secondly, the ionosphere fails to reflect the short radio waves/ TV waves which are required to transmit live television programmes. Satellites have made it possible and brought about a revolution in communication. There are geostationary satellites fitted with powerful amplifiers. The TV waves from the TV station on the ground are received by these satellites which in turn amplify these TV waves and reflect them back to the various other stations on the earth. As such the satellite communication system has made the short wavelength communication (best suited for communication) possible without any distortion. At present, India is using geostationaary satellite INSAT-IB for the purpose of TV transmission and communication.

(iii) Weather monitoring : We see that on television the pictures taken by the satellite regarding the cloud formation over the country are generally shown. These pictures are analysed by meteorologists and help them in forecasting the weather all over the country. Actually, in India the geostationary satellite INSAT-IB is equipped with powerful cameras and other instruments to send the pictures and other valuable information for sensing the weather conditions .

Note :- Now the place of INSAT - 1B is taken by the INSAT - 1D for all practical purposes.

Evolution of Life : The different organisms that we see today in the present form are here on account of gradual and orderly changes that have been taking place to change them from one form to another over a period of millions of years. We find many different kinds of living organisms which differ in size, shape, structure and habits. Living organisms are found practically everywhere- on earth, under the earth, in water, in air. They are adapted to that particular area where they are found. For example, the organisms that can live in deserts, may not live in mountains and in water. We also find that each type of organism has its own characteristics.

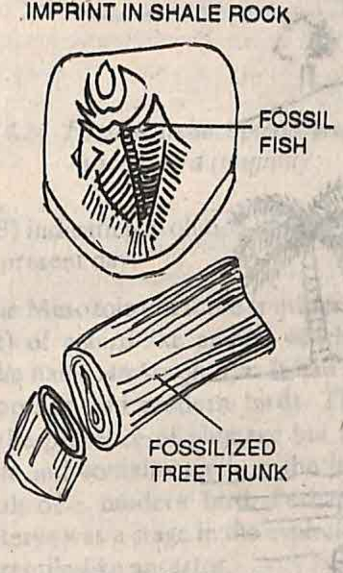

Fig. 4.22 Fossils.

Scientists have gathered overwhelming evidence that life on the earth 60 million years ago was quite different from what it was when man-like mammals first appeared about one million years ago and from what it is at present. The appearance of fossils in the sedimentary rock layers not only indicates the type of plant and animal life which existed at a given time but, also reveals the gradual changes in living beings from the time they first appeared on the earth. Evolution refers to these gradual changes in life. Fossil evidence of plant and animal life in layers of rocks have contributed important data about life on the earth in prehistoric times.

Bones or imprints of animals and plant fossils found in the lowest layers suggest the kind of plants and animals which first existed. Fossils found in subsequent, higher layers of rocks indicate the absence of some that had formerly existed, the change in original forms and the appearance of new forms. Thus we find that *organisms change with passage of time and with changes in their environment. This is called organic evolution.* Using fossil evidence as criteria, life on the earth has been divided into the eras (periods) (as shown in the chart below and

ERA	CHARACTERISTIC FAUNA AND FLORA
Cenozoic (present day to 60,000,000 B.C.)	The age of man. Modern plants and animals. First appearance and development of mammals (except man). The prehistoric horse, Eohippus, appeared. Birds flourished.
Mesozoic (60,000,000 B.C. to 230,000,000 B.C.)	Appearance of egg-laying mammals, bird-like creatures that somewhat resembled reptiles. Era of huge reptiles, dinosaurs, etc. Modern insects flourished. Lush growth of water plants. Appearance of primitive seed-bearing plants.
Palaezoic Era of coal formation (230,000,000 B.C. to 505,000,000 B.C.)	Era of giant amphibians and insects Invertebrates predominant in the waters. Primitive sharks and other primitive fish-like creatures. Abundance of coral, trilobites. Crustaceans appeared. Rich and giant fern and horsetail growth on land.
Proterozoic (505,000,000 - B.C. to 2,000,000,000 B.C.)	No sign of land life. Primitive marine invertebrates – algae, sponges, corals, small starfish.
Archaeozoic	No fossils found. Probable era of one-celled life.

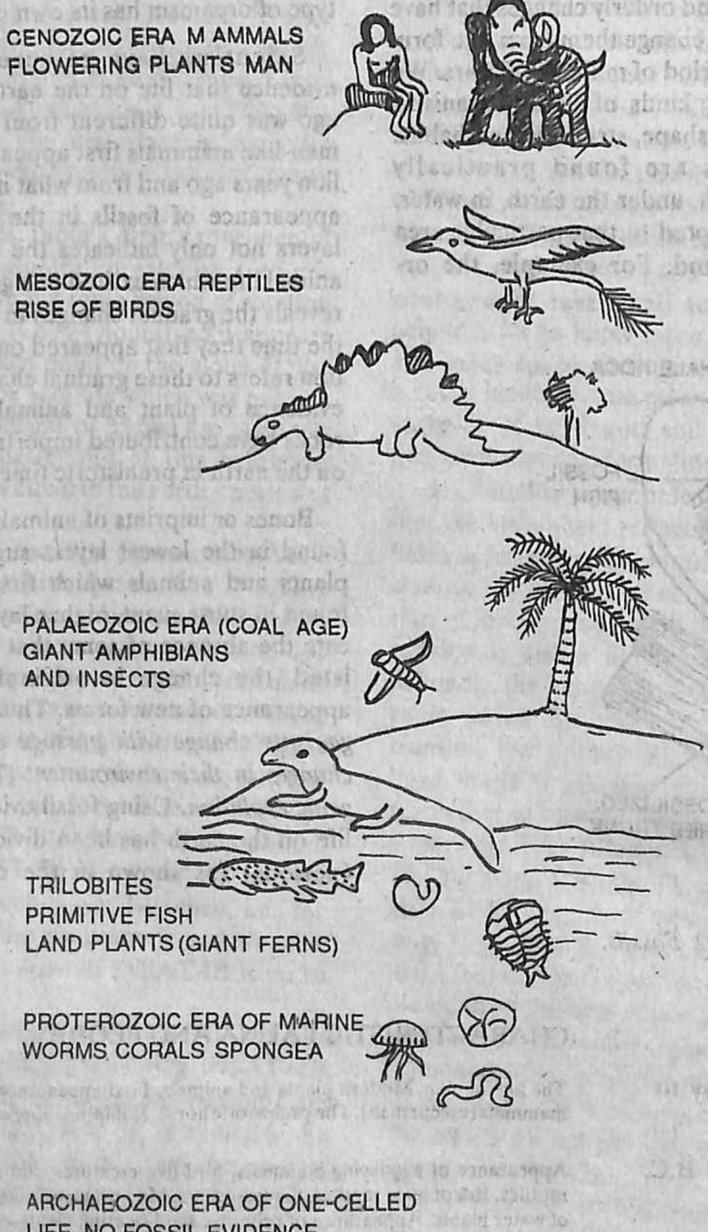

Fig. 4-23 : Evolution: the nature of change.

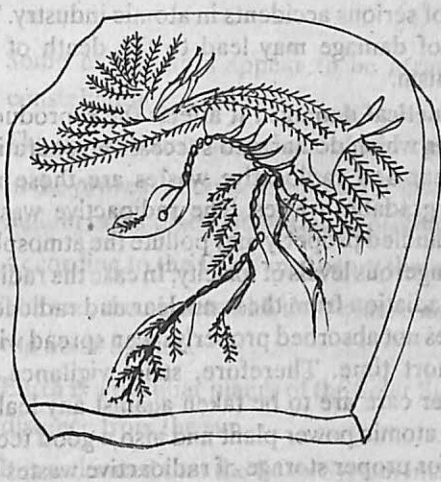

Fig. 4.24 Fossils-Archaeopteryx ancestor of modern bird (imprint)

Fig.4.23) indicating evolution of life on the earth till the present day.

In the Mesozoic era there is evidence (a fossil imprint) of a bird-like animal which has been given the name *Archaeopteryx*. It had features of both reptiles and modern birds. The imprint shows the presence of plumage but the skull is reptilian and contains teeth in the jaws, unlike the beak of a modern bird. Perhaps the Archaeopteryx was a stage in the evolution of birds from a reptile-like ancestor.

The Mesozoic period seems to have lasted for about 130 million years. Then the climate over the entire earth began to change again and the Cenozoic era began. Periods of extreme cold occurred, resulting in scarcity of food and killing of numerous huge reptiles and large plants. The surface of the earth changed. Mountain ranges such as the Himalayas and Alps appeared, as well as more continents of land.

Fossil and rock formations provide evidence that there was probably a land connexion between North America and the northern part of Europe, and also between North America and Asia. The North and South Americas were probably entirely separated.

Mammals, similar to those now in existence, began to appear. Many modern birds inhabited the sky and treetops. There were all types of invertebrates on land and in the air. Ancestors of every modern type of vertebrate inhabited the part of the earth's crust to which it was best adapted for survival. Flowering plants of every variety, not nearly as huge as their predecessors, grew in all habitats.

Later in the Cenozoic era, man-like mammals began to appear in various parts of the earth (about 1 million years ago). Fossil skulls and other skeletal structures have been discovered. These indicate that earliest man, our ancestor, resembled modern man physically but also bore some resemblance to less highly specialised primate mammals, the anthropoid apes.

Again, drastic changes in climate occurred. Huge glaciers spread from the poles, melting and retreating at intervals. Each time the land surface was covered by the massive sheets of ice, vegetation and some animal life died. Other animals fled before the oncoming glaciers to an environment in which they could adapt themselves to live. During the warm periods between glaciers, other plants and animals grew and flourished.

In the most recent part of the Cenozoic era came the ancestors of modern man who had the ability to adjust to their environment and to control the factors in this environment.

Recycling of Waste Materials

Waste Materials : Green plants receive the sun's energy and convert it into food energy. This food energy is utilized by various forms of life. These various forms of life after utilizing the food energy excrete waste products. Plants and animals also on their death become waste materials. On the other hand, by man's various activities a number of waste materials such as smoke, toxic fumes, chemicals, etc. are produced. These waste materials can be broadly classified under the following two heads:

1. Biodegradable Wastes.
2. Non-Biodegradable Wastes.

Biodegradable Wastes : Biodegradable wastes are those waste materials which can be broken down to simpler non-poisonous substances by the action of certain bacteria and can be utilized again, such as cowdung, etc.

Non-Biodegradable Wastes : Non-Biodegradable wastes are those waste materials which cannot be degraded into non-poisonous substances, for example, DDT and other chemicals used to kill harmful insects.

Recycling of Waste Materials : The dead plants and leaves undergo decomposition and produce humus that mixes with the soil and make it more fertile. The plant and animal wastes are also utilized in preparing the manures. Cowdung, the waste product, is utilized and recycled to produce *gobar* gas. Preparation of compost is also a good example for recycling of biodegradable wastes.

Nuclear and Radioactive Waste and Technique for Proper Storage of Radio-active Wastes : Radioactive substances emit penetrating high energy radiations that have harmful effect on living beings. Keeping in view of the world-wide development of atomic industry and the testing of atomic warfare weapons the fear of the effect of such radiation has increased many times.

Radiation damage to a living organism may be of the following two types:

1. Pathological damage : It requires comparatively large radiation doses and with the exception of atomic warfare, can be expected only in case of serious accidents in atomic industry. This type of damage may lead to the death of that organism.

2. Genetical damage : It affects the reproductive organs which do harm to successive generations. Nuclear and radioactive wastes are those non-biodegradable wastes. The radioactive waste if not handled properly may pollute the atmosphere to dangerous levels of toxicity. In case the radioactive radiation from these nuclear and radioactive wastes not absorbed properly it can spread widely in short time. Therefore, strict vigilance and proper care are to be taken against any leakage from atomic power plant and also a good technique for proper storage of radioactive wastes is to be employed. Thick concrete wall around the nuclear reactor is generally constructed in order to prevent any possibility of radiation coming out from it.

Role of solar energy in origin and Sustenance of Life : We have already studied that the earth is at the right distance from the sun to retain water. The presence of water has helped to evolve life on the earth and develop it into the presentday form. The plants on the earth require CO_2 of the atmosphere to prepare their food in the presence of sunlight, the process is called photosynthesis. During the process of photosynthesis oxygen is liberated. This has played an important role in the evolution of higher forms of life. Today, the presence of oxygen is very essential for the sustenance of life. Thus, the solar energy plays an important role in the origin and sustenance of life on the earth.

SUMMARY

1. Cluster of stars is called a galaxy.
2. There are about 10^{11} galaxies which form the universe.
3. The total number of stars in the universe is about 10^{22}.
4. Light year is the distance travelled by light in one year. 1 light year = 9×10^{12} km (approx.)
5. Milky Way is the name of one of the galaxies of the universe of which the sun is a star.
6. The two common shapes of galaxies in the universe are spiral and elliptical.

7. Some of the stars appear to be arranged in groups or in beautiful patterns which are called constellations.
8. The dense contracting cloud of hydrogen and helium gases is called protostar.
9. In the process of contraction and collision high temperature is attained and fusion of hydrogen into helium takes place, liberating enormous amount of energy. At this stage protostar is called star.
10. According to the Big Bang theory the universe is expanding.
11. The sun, the planets with their moons and other heavenly bodies together constitute what is called the Solar System.
12. Earth is a peculiar planet of the Solar System on which life exists. It is on account of its appropriate distance from the sun.
13. It is estimated that the Solar System including the earth is about 4500 million years old.
14. The three major layers of the earth are (i) Core (ii) Intermediate Mantle (iii) Outer Crust.
15. The outer layer of the earth consists of four divisions, e.g. (i) lithosphere (ii) hydrosphere (iii) biosphere and (iv) atmosphere.
16. The action of the sun's energy to convert O_2 to O_3 helps in blocking the ultraviolet radiation to enter the earth's atmosphere.
17. The atmosphere consists of four layers, e.g. (i) troposphere (ii) stratosphere (iii) ionosphere (iv) exosphere. It consists of 78% N_2, 21% O_2, 0.9% argon and 0.1% other gases.
18. The heating up of the atmosphere by CO_2 is termed as greenhouse effect.
19. The purposes of space exploration are manifold, the main being (i) collection of information about other planets and outer space (ii) satellite communication (iii) weather monitoring.
20. Evolution refers to the gradual changes in different forms of life.
21. Fossil evidence indicates that organisms change with passage of time and change in environment. This is called organic evolution.
22. The waste products are (i) biodegradable and (ii) non- biodegradable. The biodegradable products can be recycled in nature, such as cowdung is used to produce *gobar* gas. The non- biodegradable products such as radioactive wastes, chemical wastes, etc. remain as such in nature.
23. Solar energy plays an important role in the origin and sustenance of life on the earth.

QUESTIONS

Very Short Answer Type Questions

1. Write the names of two gases from which a star begins to be formed.
2. Name the planet which does not contain carbon dioxide in its atmosphere.
3. What will happen if the amount of CO_2 increases in air?
4. What are the two most common shapes of galaxies?
5 What is a light year?

6. What is a constellation ? Name any one constellation.
7. Name the galaxy of which the sun is a star. What is the approximate number of stars contained in this galaxy?
8. What conclusion can you draw from the red shift in the spectra of glaxies?
9. In the universe it is found that there are some infinitely dense points from which no light is able to get cut. What name has been given to them?
10. Name the gas found in highest percentage in the atmosphere.
11. What is the use of conversion of oxygen to ozone in the atmosphere?
12. What is greenhouse effect?
13. When was the first manned satellite launched by the USSR?
14. Name the planet which is nearest to the sun.

Short Answer Type Questions

1. What is the Solar System ? Name the planets situated between the sun and the earth.
2. Differentiate between galaxy and constellation.
3. Draw a schematic sketch to show the Great Bear (Saptarishi).
4. Explain the formation of a star from a protostar.
5. What are the evidences which explain the hypothesis that the universe began in a Big Bang.
6. Draw the shape of Ursa Major showing the positions of stars.
7. Why does the size of a star change in the radiant phase?
8. Why cannot we use the natural satellite, moon, for communication purposes?
9. Give the main difference between biodegradable and non- biodegradable waste products.
10. The velocity of light is $3x10^8$ m /sec. If the sunlight takes 8 minutes to reach the earth, calculate the distance of the sun from the earth in light years.
11. What is the use of the ionosphere?
12. How can you say that iron is in the solid form inside the core of the earth and how it remains in the solid form inside the core of the earth inspite of high temperature there?
13. What is the difference between meteors and meteorites?
14. What are asteroids?
15. What is the reason that the earth is a unique planet on which life exists?
16. What are two forces under which a star remains in equilibrium and radiates energy for thousands of millions of years?
17. Draw the shape of Orion showing the position of stars.

Essay Type Questions

1. Give a short account of the exploration of the moon.

2. Mention in brief the application of Space Science.
3. Give a short account of the earth's atmosphere.
4. What is the structure of the earth? Describe the three major layers of the earth.
5. What are the physical and biological components of the earth? How are these dependent on each other ?
6. How is the earth estimated to be approximately 4500 million years old ?
7. What is the Red Giant Phase of a star ? When will the sun enter this phase ?

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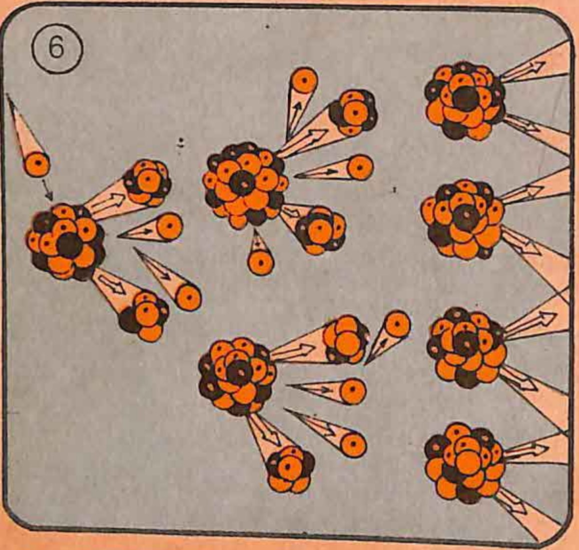

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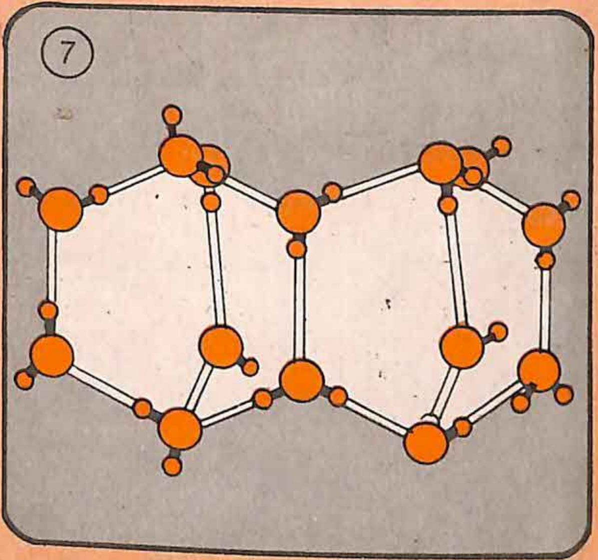

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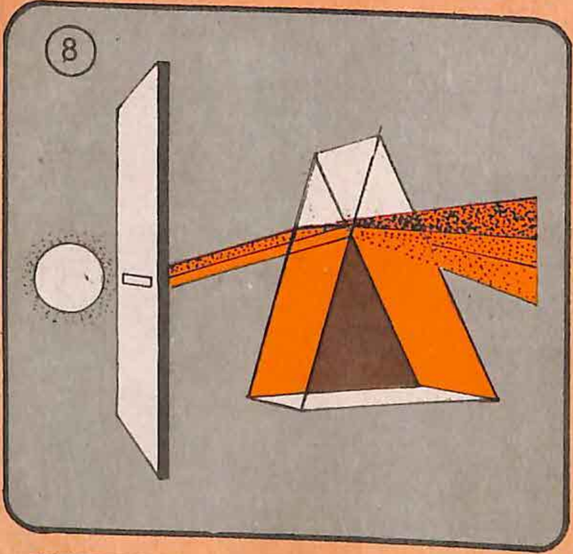

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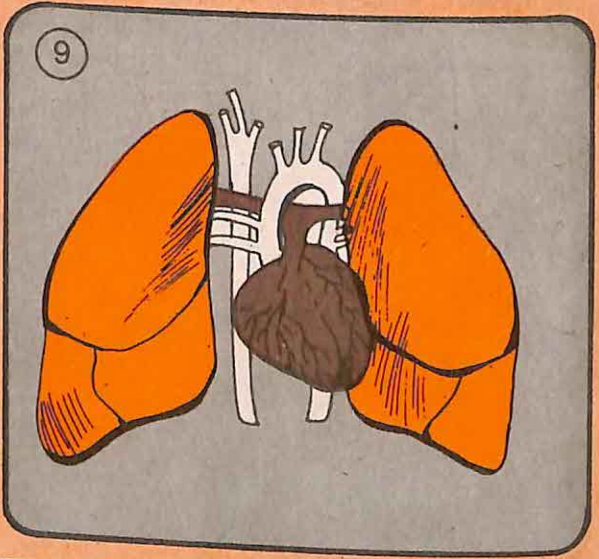

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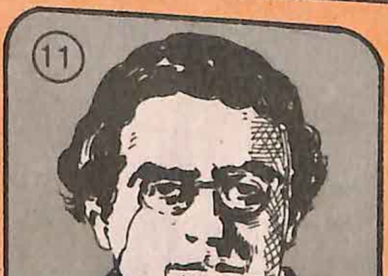

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